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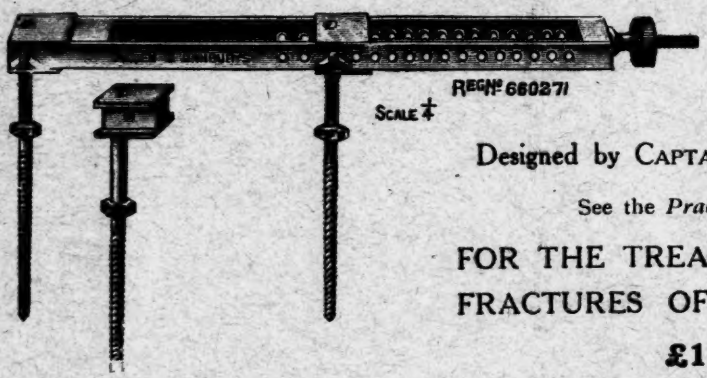

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THOMAS VICARY.

1490–1562.

THOMAS VICARY, by virtue of his age and position, was leader of the band of surgeons who desired their calling advanced to a better position under the Tudor dynasty. He seems to have gained his influence by his personality more than by his writings. In this respect he differed from Gale and Clowes, who were rough and pushing; from Halle, who was active as a satirist and persecutor of quacks; from Banister, a polished gentleman; and from Read, who died too young to do more than lend the energy of youth to the movement in which all were interested.

The facts of Vicary's life are few, but they have been diligently gleaned by Dr. J. F. Furnivall and by Dr. Norman Moore.

He was probably born in Kent at some time between the years 1490 and 1500, as the first notice of him occurs in Manningham's Diary, where he is stated to have been "at first a meane practiser in Maidstone until the King advanced him for curing his sore legge."

In London he was admitted to the Barbers' Company, where he rose rapidly until he became Master in 1530. In 1540 the Company of Barbers was united with the Guild of Surgeons to form the United Company of Barber Surgeons. This union lasted until 1745, when it was dissolved, the Barbers' Company continuing, as it does to this day, on the original site in Monkwell Street, whilst the Surgeons built themselves a new Hall in the Old Bailey. Vicary was nominated the first Master of the United Company, and he was re-elected to the Mastership in 1546, in 1548, and in 1557, a proof of the high esteem in which he was held by his contemporaries, for no one after him was ever chosen so often.

In 1528 he was appointed surgeon to King Henry VIII, and two years later he was granted a reversion of the places, held by Marcellus de la More, of Serjeant Surgeon and chief Surgeon to the King. The reversion fell in during the year 1535. Vicary retained the post until his death in 1561, and thus served under Henry VIII, Edward VI, Mary, and Elizabeth.

Like the Court servants of the time, but to a lesser degree, he was rewarded by grants of confiscated church property. In 1539 he obtained the beneficial lease for twenty-one years of the rectory house and tithes of the recently dissolved Boxley Abbey in Kent. The Abbey had been celebrated for its miraculous rood, with eyes stirring like a living thing, its body bowing, its forehead frowning, and its lower lip moving as if about to speak. In 1541 he bought additional lands at Boxley from Sir Thomas Wyatt, the poet, and in 1542 he was appointed with his son, William, a Bailiff of Boxley Manor, with an annuity of £10 a year. In 1557 he was rich enough to lend money to the United Company when it had got into financial difficulties, and

there is a minute that " Mr. Thomas Vicary shal paye and discharge the debtes of the howse and shal haue the plate of the Crafte in pawne or pledge untyl suche tyme as the sayde summe of monnie bee unto hym payde agyne." In the following year he lent £100 to his brother-in-law, Thomas Dunkyn, yeoman, of Shoreditch, and about the same time he bought a house and some land next to Boxley Church.

In 1548, after the confiscation of the Hospital by Henry VIII, the citizens of London determined to re-endow St. Bartholomew's Hospital at their own cost, and Vicary was appointed a governor, with three surgeons under him, William Cartar, Thomas Bailey, and George Vaughan. He must have carried out his duties to the satisfaction of the Mayor and his brethren the Aldermen, because in 1552 he was chosen " one of the assistaunts of this howse for the term of his life," a position rarely, if ever again, bestowed upon an active member of the staff. He lived in the Hospital, was assigned the old conventual garden for his use, and probably carried out the same duties that had been performed by the Master of the Hospital in pre-reformation times.

He married twice: (1) The sister of Thomas Dunkyn, by whom he had a son, William, who lived to manhood, was probably a surgeon, but died before his father; and (2) Alice Bucke, whom he married in 1547. She survived him, and inherited most of his property.

Vicary's will is dated January 27, 1560–1, and was proved on April 7, 1562, so that he probably died about the end of the year 1561. He bequeathed his best gown to Robert Balthrop, whose monument is behind the organ in the church of St. Bartholomew-the-Less; his second-best gown to Thomas Bayly; his gown faced with black satin to Robert Muddesley; his best cloke guarded with velvet to George Bucke; his doublet of crimson satin to George Vaughan, with other little mementoes, which show that he was on terms of friendship with his colleagues. To the United Company itself he bequeathed his copy of "Gui de chauliac, ii billes, ii bowes; ii sheafs of arrows; ii braces or arm-guards; ii shooting gloves; ii skulls; one hand gun and one jack or quilted coat."

Vicary is best known as the author of *A profitable Treatise of the Anatomie of Man's body*, which is generally quoted by the short title of the later editions as *The Englishman's Treasure*. The earliest known edition is that of 1577. It is dedicated to Sir Rouland Hayward, the president, and the governors, by William Clowes, William Beton, Richard Story, and Edward Bayly, then surgeons to St. Bartholomew's Hospital.

There has been some question as to the real authorship of this work. The ate Dr. F. J. Payne showed conclusively that it is taken mainly from an unknown author, writing in English not later than the fourteenth century, who based his work upon Lanfrank and Mondeville. The unfinished manuscript of this work was actually in the possession of Dr. Payne, who gives two theories: "(1) Vicary was in possession of a copy of this treatise, of which he made an abridgement, using the same words—sometimes not understanding them—and brought it out as his own. One does not like to think of Vicary as an actual literary impostor, and there is perhaps another supposition; (2) Possibly Vicary did not profess to be the author. The only absolutely known printed edition

THOMAS VICARY.

From a crayon enlargement by A. T. Young, in the possession of D'Arcy Power, F.S.A.

was brought out fifteen years after his death by his colleagues at St. Bartholomew's Hospital, and they may have found a manuscript tract which they regarded as Vicary's—though he never laid claim to it—and published it as his." John Halle, a contemporary and friend of Vicary, however, makes the following statement in the prologue to his " very frutefull and necessary briefe worke of Anatomie," printed in 1565—that he was somewhat encouraged to publish it " by the example of good Maister Vicarie, late sargeante chyrurgien to the queenes highnes; Who was the firste that euer wrote a treatyse of Anatomie in Englyshe (to the profite of his brethren chirurgiens and the helpe of younge studentes) so farre as I can learne." Vicary's treatise, therefore, was known as early as 1565, and it is stated that a transcript in manuscript was made from an edition supposed to have been published in 1548, although no such edition is now known to exist. The most plausible explanation appears to be that Vicary edited the fourteenth century author in exactly the same way as Halle states that he himself edited Lanfrank—that is, he borrowed various manuscripts, compared them diligently, omitting some things, adding others, and then allowed his finished labours to be circulated in manuscript in much the same way that Sir Thomas Browne permitted the *Religio Medici* to be circulated a hundred years later. The prestige of Vicary's name made it worth while in 1577 for his colleagues to print from one of the manuscripts, and the result was so successful that a book, which was in reality worthless, was reprinted in 1580, 1586, 1613, 1626, 1633, and 1641, which shows the low standard of anatomical knowledge ruling amongst Barber Surgeons in the sixteenth century.

Before dealing with anatomy proper, Vicary enumerates the accidents and qualities required in a good surgeon as they had been handed down from time immemorial and had gradually become standardized. " All Authors doe agree that a Chirurgion shoulde bee chosen by his complexion and that his complexion bee verie temperate and all his members well proportioned. For Rasis sayeth Whose face is not seemely it is unpossible for him to have good manners. And principally it is necessarie that he bee a good liver and a keeper of the holye commaundements of God, of whome commeth all cunning and grace, and that his bodye bee not quaking, and his handes stedfast, his fingers long and small and not tremblinge; and that his left hande be as readie as his right hande with al his lymmes able to fulfil the good workes of the soule. And I doo note four thinges moste specially that every Chirurgion ought to have. The first that he be learned; the seconde that he be expert; the thirde that he be ingenious; the fourth that he be well mannered. The firste (I sayde) he ought to be learned and that he knowe his principles not only in Chirurgery but also in Physicke that he may the better defende his Surgery. Also he ought to be seene in Naturall Philosophie and in Grammar, that he speake congruitie in Logike. Also he must knowe the Anatomie; for all Authors write against those Surgeons that worke in mans body, not knowing the Anatomie; for they bee likened to a blinde man that cutteth in a vine tree for he taketh more or less than he ought to doe. The seconde, I sayde, he must be expert, for he ought to knowe and to see other mens work and after to have use and exercise. He ought also to be ingenious or wittie for all thinges belonging to Chirurgerie

may not be written nor with letters set foorth. He must be wel mannered and that he have all these good conditions here folowing; First, that he be no spous-breaker nor no drunkard. For the Philosphers saye amongst all other thinges beware of those persons that followe drunkenness, for they be accompted for no men because they live a life bestiall. Likewise a Chirurgion must take heede that hee deceive no man with his vaine promises for to make of a smal matter a great, because he would be counted the more famous. And amongest other thinges they maye neither be flatterers, nor mockers nor privie backbyters of other men. They must be as privie and as secret as any Confessour of al thinges that they shal eyther heare or see in the house of their Pacient. Also they shoulde doe their diligence as wel to the poore as to the riche. They shal never discomfort their patient and shal commaunde all that bee about him that they doe the same, but to his friendes speake truthe, as the case standeth. They must also be bold in those things whereof they be certaine and as dreadfull in all perilles. They may not chide with the sicke but be alwayes pleasaunt and merie. They must not covet any woman by waye of vylanie and specially in the house of their Pacient. They shal not for covetousnesse of money take in hande those cures that be uncurable, nor never set any certaine day of the sickeman's health for it lyeth not in their power. They must also be gracious and good to the poore and of the riche take liberally for bothe. And see they never prayse themselves for that redoundeth more to their shame and discredite than to their fame and worship. For a cunning and skilful Chirurgion neede never vaunte of his dooings for his workes wyll ever get credite ynough. Likewise that they despise no other Chirurgion without a great cause, for it is meete that one chirurgion should love another as Christe loveth us all. And in thus dooing they shall increase both in vertue and cunning to the honour of God and worldly fame. To whome he bring us all. Amen! Heereafter foloweth the Anathommie."

The portrait of Vicary which illustrates this account of him is a careful enlargement by Mr. A. T. Young of the figure in Holbein's picture which still hangs in the Barbers' Hall in Monkwell Street. It was painted about 1545 to commemorate the Union of the Barbers and Surgeons, and is therefore a faithful likeness of Vicary. He is represented in his Master's gown, with the usual head covering which was worn under the hat or cap, as may be seen in the portrait of John Halle, p. 182 of this Journal,

GUNSHOT WOUNDS OF THE CHEST.

By P. T. CRYMBLE, Belfast.

The following paper is based on fifteen months' work in a base hospital in France and twelve months' in a similar hospital at home. In France the cases were usually seen in from one to seven days from the time of being wounded, and the *x*-ray examination was made with the object of determining the condition of the thorax and of estimating the progress of the case. At home the examination was made as a preliminary to the removal of a foreign body. Many of the skiagrams were shown at a demonstration before the Etaples Medical Society in March, 1916, but since then the material has increased in amount, and one has had the experience of the later results.

In all cases the usual physical examination was made at the time of the *x*-ray examination, in order that the skiagram might be correlated with the physical signs. The *x*-ray examination was repeated in many cases, so that records were obtained of the various stages in the progress of the condition. The author is greatly indebted to his colleagues on the staff of the hospital, without whose co-operation the material could never have been obtained; and his thanks are due to Corporal Lounds for his great assistance in the *x*-ray examination, and to Corporal Waterhouse for the skill and enthusiasm with which he produced the records.

Material upon which the Paper is Based.

Hæmothorax	59 cases
Hæmopneumothorax	19 „
Traumatic infarct	15 „
Lung collapse	15 „
Pyopneumothorax	8 „
Pneumothorax	7 „
Subphrenic abscess	4 „
Various	30 „
Localization of foreign bodies ..	54 „
Total cases ..	211

Apparatus.—In France a Butt outfit with a 16-inch coil was used. Power was obtained from a 15 H.P. oil engine which worked a dynamo producing a continuous current at 220 volts. Using the mercury interrupter, one obtained 2 to 4 milliampères in the secondary circuit. The unipolar electrolytic break gave up to 10 milliampères in the secondary circuit, but it frequently stopped working in the middle of the exposure, and was not used. An accelerator screen was employed, and a five-second exposure gave a good result, so that the skiagram could be obtained whilst the patient held his breath. The vertical screening stand was indispensable, and enabled one to carry out the examination with very little disturbance to the patient. It was

fitted with a stereoscopic shift, and as a rule the anticathode was about 22 inches from the plate.

Reduced prints were made of the 15 × 12 in. negatives, and the accompanying illustrations have been made from these prints. Unless otherwise stated, the rays have passed dorso-ventrally to the plate, which was in contact with the anterior chest wall. The right side of the chest is on the left side of the picture.

The Diaphragm.—The movements, shape, and position of the diaphragm usually show some alteration in wounds of the chest, and inspection of the two cupolæ of the diaphragm on the fluorescent screen is one of the most important parts of the *x*-ray examination of the chest.

The right cupola, bounded above by the clear lung area and below by the opaque liver, is not to be distinguished from the general abdominal opacity except in the presence of a right subphrenic gas-bubble. Superiorly the cardiac shadow blends with it, and makes an angle (cardio-hepatic angle) of almost ninety degrees slightly to the right of the vertebral column.

The left cupola is normally defined by the gastric gas-bubble. Superiorly it is overlapped to a considerable extent by the heart, and lateral to the heart the left lung area defines it.

Immobility or Deficient Movement of the Diaphragm.—This usually follows a perforating wound of the thorax, the diaphragmatic cupola on the injured side being affected. Frequently there is complete immobility, but in wounds of the lung apex only slight deficiency may be noticeable. It is also an accompaniment of lung collapse, being found on the same side as the collapse.

Comparison with the sound side of the chest will usually enable one to detect the defective movement, but the presence of any large supra-diaphragmatic lung area opacity may render the diaphragm invisible and prevent the observation being made. If the opacity be due to fluid in the pleural cavity, the diaphragm may be visible in the lying position. On the left side the presence of a stomach gas-bubble will enable one to note the position and movement of the diaphragm where the left lung area is opaque.

What is the explanation of this defective movement? Is it a protective reflex fixation of the diaphragm in the position of expiration, or is it the result of deficient air entry into the injured lung? The former explanation would seem to account for those cases where the lung area above the immobile diaphragm is clear and there is no evidence of any obstruction of the air entry into the lung. *Case* 14, recorded in ***Fig.*** 307, is an example of this condition. On the other hand, it would seem probable that if a lung is unable to expand owing to the presence of fluid in the pleural cavity or to laceration of its substance or to obstruction of its bronchi, then during the inspiratory enlargement of the thoracic cage, the diaphragm will be drawn upwards and the mediastinum will be drawn towards the affected side. This retraction of the mediastinum and diaphragm towards an opaque lung area is best seen in lung collapse (***Fig.*** 296), and the diaphragmatic elevation is also an accompaniment of hæmothorax.

Adhesions between the costal and diaphragmatic pleura, or between the visceral and diaphragmatic pleura, will cause permanent defective movement and marked alteration in the shape of the cupola during inspiration.

Shape and Position of the Diaphragm.—The right cupola of the diaphragm normally occupies a higher position than the left, and it shows occasionally some irregularity of outline, due possibly to the shape of the underlying liver. The left cupola has a regular curved outline, and may surmount a stomach gas-bubble or stomach and colon gas-bubbles. During inspiration very little alteration in the shape of the diaphragmatic outline takes place. There is simply a descent of the abdominal contents without a flattening out of the diaphragmatic cupolæ.

Costo-diaphragmatic adhesions result in a flattening of the cupola during inspiration, and adhesions between the visceral and diaphragmatic pleura anchor the diaphragm to the lung and cause marked angulation during inspiration (*Fig.* 323).

Marked elevation of the right cupola was noticed in a case of subphrenic abscess (*Fig.* 311), where a large quantity of gas accumulated between the liver and the diaphragm, and again in a case of injury to the right phrenic nerve (*Fig.* 309). Marked elevation of the left cupola was noted in left lung collapse (*Fig.* 297), and could be detected both radiographically and by percussion by the abnormally high position of the stomach and colon gas-bubbles.

Injury to one side of the chest causes diminution in the inspiratory descent of the diaphragm on the affected side. No case has shown depression of the diaphragm beyond the normal inspiratory position, nor has any cupping of the upper surface of the diaphragm been observed.

It is rather difficult to explain the high immobile diaphragm which is the usual result of a wound of the chest. It is not a reflex contraction of the diaphragm to prevent movement, comparable to the rigid abdominal muscles found with peritonitis, since the diaphragm is in the fully relaxed position. Indeed, if it is a reflex, it must be a reflex relaxation of the muscle fibres. There is, however, a second possible explanation of the high immobile diaphragm—namely, that the diaphragm is unable to descend because the air cannot enter the lung owing to the compression of the latter by the fluid in the pleural cavity. In a case of apical traumatic infarct, each inspiratory effort was accompanied by an indrawing of the supraclavicular region and the upper intercostal spaces, and it is reasonable to assume that the diaphragm will have to labour against this abnormal negative pressure when air is unable to enter the lower lobe. Perhaps both factors come into play. Strong support is given to the reflex theory by those cases where the immobile diaphragm is unaccompanied by any other change in the lung area, or when only a small quantity of blood is present in the phrenico-costal space. One has observed several perforating wounds of the chest which at first showed only a high immobile diaphragm.

Localization of Metallic Foreign Bodies in the Thorax.—The localization may be carried out with the object of determining the anatomical position and reconstructing the track of the missile, or as a preliminary step in the removal of the foreign body. In the latter case the most important point for the surgeon is the determination of the portion of rib in closest proximity to the foreign body. This is most rapidly arrived at by screening antero-posteriorly and laterally, and then taking stereoscopic plates with the foreign body as near the plate as possible. Most intrathoracic foreign bodies would

appear to be brought to rest by the thoracic wall, and are therefore fairly accessible to the surgeon. Small fragments embedded in the region of the lung hilus will probably be left *in situ*.

The entire examination is made with the patient in the lying position, and a skin-mark is made over the most adjacent portion of rib. In taking the plates, the patient is instructed to hold his breath, and an exposure of ten to fifteen seconds, without an accelerator screen, is usually sufficient. A much longer exposure will be required in the presence of a hæmothorax.

Removal of Intrathoracic Metallic Foreign Bodies.—One of the most recent text-books on military surgery advocates no surgical interference with intrathoracic foreign bodies unless the foreign body is in the pleural cavity and is giving rise to symptoms. One's own experience, limited to ten operations for the removal of intrathoracic foreign bodies, does not disclose any difficulty in the operation, or any unfavourable complication in the convalescence. Consequently one is accustomed to undertake the removal of the foreign body when the patient complains of its presence, and when the missile is within reach of the surgeon's finger passed through a small thoracotomy opening.

Two inches of rib is resected, the pleural cavity opened, if necessary the lung incised, and the missile located by palpation. In the presence of adhesions no pneumothorax will take place; otherwise, the palpating finger will fairly efficiently block the pleura opening. Foreign bodies in the lung are easily palpated, and the intervening lung tissue is often friable, so that the finger can accomplish the loosening of the metal fragment, and forceps can extract it. After the removal has been accomplished, one closes the pleural opening and tightly sutures the overlying muscles and skin so as to prevent any communication with the outside air.

The wound of the lung appears to close rapidly, and the air is ultimately absorbed from the pleural cavity.

Changes in the Lung Areas produced by Wounds and Injuries.—The lung area is the clear space bounded medially by the mediastinum, laterally by the ribs, and inferiorly by the diaphragm. Radiating into it from the lung hilus are a number of opaque strands which are produced by the pulmonary vessels and the bronchi. The presence of fluid or gas in the pleural cavity, laceration or inflammation of the lung substance, and massive collapse of the lung, can be diagnosed by the alterations they produce in the lung area.

Where possible the patient should be examined both in the lying and sitting positions, with the rays passing dorso-ventrally, and the apparatus should be capable of giving a satisfactory result with a plate exposure of five seconds with an accelerator screen.

Fluid in the Pleural Cavity.—This gives rise to an opacity of the lung area, the extent of which varies with the amount of fluid. A very large quantity of fluid will render the whole of one lung area opaque, whilst a small collection will produce a supradiaphragmatic opacity in the sitting position. Where the whole lung area is not abolished in the sitting position, the upper limit of the fluid opacity is ill-defined and irregular, and forms a marked contrast to the clearly-defined horizontal gas-fluid junction. In large collections of fluid the clear space may be reduced to a pear-shaped area, the base of which corresponds to the lung apex, the stalk being directed towards the lung

hilus. In the lying position, fluid disseminates itself through the pleural cavity, and produces a moderate opacity of the whole lung area.

The nature of the pleural fluid cannot be determined radiographically.

Gas in the Pleural Cavity.—Gas in the pleural cavity, associated with retraction of the lung from the lateral thoracic wall, is revealed by the presence of an opaque line produced by the lateral margin of the collapsed lung, and even quite small collections of gas may disclose themselves in this way (***Fig.*** **287**). In the large pneumothorax, or in the presence of inflammatory thickening of the visceral pleura, the structure and outline of the whole lung and its lobes may be visible (***Fig.*** **286**).

Where, however, owing to fresh or old adhesions between the lung and the lateral thoracic wall, lateral collapse of the lung cannot take place, the gas tends to collect in front of the lung, and fails to alter the appearance of the lung area. In one case, a large pneumothorax was not recognized at the *x*-ray examination, but was subsequently revealed by exploratory puncture and confirmed by post-mortem examination. It was found that the lung was fixed by fresh adhesions to fractured ribs in the lateral thoracic wall, and that the gas had collected anterior to the lung.

In some cases the adhesions are unable to prevent lateral collapse of the apex (***Fig.*** **313**), or the lung may be permitted to retract upwards from the phrenico-costal space.

Gas and Fluid in the Pleural Cavity.—Gas and fluid in the pleural cavity give rise, in the sitting position, to a very characteristic picture, since a sharp horizontal line (gas-fluid junction) marks the junction of the opaque fluid with the transparent gas (***Fig.*** **280**). During screen examination this gas-fluid junction may show waves, bubbles, or splashings.

Traumatic Infarct.—This is the condition produced by contusion or laceration of the lung, and it gives rise to an opacity of the lung area involved. In ***Fig.*** **310** a traumatic infarct of the lung apex is illustrated. When the lower part of the lung is involved, some difficulty may be experienced in distinguishing a traumatic infarct from a small hæmothorax, and frequently the latter condition accompanies the former.

Pneumonia.—This gives rise to an opacity of the lung area concerned. There is no displacement of the heart.

Massive Collapse of the Lung.—Pasteur[1] has described this condition, and finds it in association with diphtheria and as a sequela of abdominal operations. The diphtheritic cases are the result of paralysis of the diaphragm, and the post-operative massive collapse is perhaps due to a reflex immobility of the diaphragm on the affected side. Sir John Rose Bradford has pointed out the frequency with which this condition accompanies gunshot wounds of the chest,[2,3] and was the first to suggest massive collapse as the explanation of certain puzzling radiograms, the outstanding feature of which is opacity of the lung area with retraction of the heart towards the opaque side.

Radiograms of fifteen of these cases have been obtained. In twelve the left and in three the right lung was affected. In ten cases the collapse was on the side opposite to that injured (contralateral collapse), and in five the collapse was on the same side as the injury (homolateral collapse). The missile may penetrate the thoracic cavity, or may merely give rise to a contour track.

As a rule the lower lobe alone is affected, but in one case the whole lung was opaque, and in one case the apex alone was affected. The evidence obtained from these cases is summarized in the following paragraphs.

1. Opacity of a lung area, associated with a high and immobile diaphragm and with retraction of the mediastinum towards the opacity, may follow a contour wound of the same side of the chest, or a contour wound or a penetrating wound of the opposite side of the chest.

2. The opacity gradually disappears, and the lung area is normal in from one to two weeks.

3. The gradual disappearance of the opacity is independent of the changes taking place in the opposite side of the chest (*Figs.* 287, 288, where the right pyopneumothorax continued to develop and the left lung opacity disappeared).

4. Complete paralysis of all the muscles of respiration, except the left half of the diaphragm, did not produce any opacity in the lung areas (*Fig.* 309).

5. The lower lobe of the left lung is most frequently affected.

6. When the left lung is affected, there is a marked increase in the area of cardiac pulsation, due to the retraction of the lung from the anterior surface of the pericardium.

7. As a rule a man lies on the unwounded side, and the restriction of the respiratory movements on the dependent side may be a factor in producing contralateral collapse.

8. The following physical signs accompany the opacity: Inspection—diminished respiratory movement in the affected region. Percussion—dullness posteriorly over the opaque area. Auscultation—weak breath sounds or tubular breathing over the opaque area, occasionally accompanied by râles or rhonchi.

9. One case of contralateral opacity with retraction of the heart developed pneumonia in the affected lung, and died. The post-mortem showed left lobar pneumonia and pericardial effusion. On the posterior aspect of the right chest there was a large gutter-wound, which was entirely superficial to the ribs.

10. Examination of this series of cases still leaves the cause of the opacity uncertain.

Bilateral Affections.—

Contralateral collapse	6 cases
Wound on opposite side to hæmothorax ..	5 ,,
Double hæmothorax	2 ,,
Left hæmothorax—right tubercle ..	1 ,,
Right hæmothorax—pericardial effusion ..	1 ,,
,, infarct—left collapse	1 ,,
,, pneumothorax—left collapse ..	1 ,,
,, effusion—left collapse	1 ,,
,, apical collapse—left apical traumatic infarct	1 ,,
,, empyema—left pneumonia ? ..	1 ,,
,, pneumothorax—left effusion ..	1 ,,
Total cases	21

Contralateral lung collapse accounts for a large number of bilateral affections, and in some of these the wounded side showed injury to the lung, or a collection of fluid, or gas and fluid, in the pleural cavity. The next largest group includes cases of double hæmothorax and of hæmo-

thorax with the entry wound on the opposite side. As a rule the missile enters the back, passes to the opposite side superficial to the spine, and then penetrates the thoracic cavity. In its passage it may injure both pleural cavities and produce double hæmothorax, or the track may be contour on one side and penetrating on the other. In two cases the missile entered the breast, and, after a contour track, penetrated the thoracic cavity of the opposite side.

Course of the Missile.—It is sometimes extremely difficult to reconstruct the thoracic track of a missile, owing to the possibility of free movement in the pleural cavity, and to the tendency of the ribs to produce deflection.

The following cases illustrate these points :—

1. A rifle bullet entered the right back 14 cm. to the right of the spine and on a level with the nipple. The bullet was removed from the left breast lateral to the nipple. An extensive left hæmothorax was produced, the opacity extending up to the fourth costal cartilage, and being accompanied by slight retraction of the heart to the left. No rib fracture could be detected, but one believes that the bullet passed superficial to the spine, and was then deflected by a rib through the left thoracic cavity.

2. A shrapnel ball penetrated the right back, superficial to the seventh rib and 7 cm. to the right of the spine. It was localized in front of the neck of the left twelfth rib, and a fracture of the left seventh rib lateral to the neck was present. The ball had passed transversely from right to left, superficial to the spine, fractured the seventh rib on the left side, and entered the pleural cavity, through which it descended to its resting-place.

Physical Signs.—Inspection, palpation, percussion, and auscultation were carried out at the time of the *x*-ray examination, so that the ordinary physical signs might be correlated with the radiogram, and a short description of the usual signs accompanying the various pathological conditions is given below. Deficient movement of one side of the chest is one of the most reliable signs, and always indicated the site of the pathological change. Surgical emphysema obscured the percussion results by giving rise to a tympanitic note, and radiography alone could be relied on to give an accurate diagnosis in such cases. As a rule surgical emphysema accompanied pneumothorax.

Auscultation would appear to be somewhat unreliable, since the same pathological condition may give rise to tubular breathing or weak breath sounds, or a patient may show a change from tubular breathing to weak or absent breath sounds. It has been suggested that this tubular breathing due to lung collapse, and that when the collapse passes off, the weak breath sounds of fluid in the pleural cavity appear. *Case* 9 (*Fig.* 296)—a typical lung collapse—does not support this theory, since it showed weak breath sounds and no tubular breathing.

Hæmothorax (59 cases).—

X-ray Appearances on Affected Side.—Diaphragm high and immobile. Heart displaced to sound side. An opacity of the lung area which in the sitting position occupies the whole lung area or leaves a variable amount of the upper region clear. Upper margin of the opacity irregular.

Percussion.—Posterior—dullness up to the inferior angle or spine of the scapula. Anterior—skodaic resonance (lower pitched and tympanitic).

Auscultation.—Posterior—breath sounds weak or absent ; in 5 cases

tubular breathing changing to weak or absent breath sounds; in 9 cases tubular breathing. ANTERIOR—weak breath sounds.

Traumatic Infarct (15 cases).—

X-ray Appearances.—Opacity in region of lung wound. In some cases fragments of bone or metal in the centre of the opacity. Posture has no effect on the opacity. Diaphragm immobile or acting.

Percussion.—Normal, or dullness over infarct.

Auscultation.—Weak breath sounds over infarct; tubular breathing in 1 case; adventitious sounds in 2 cases.

Surgical Emphysema.—Present in 3 cases.

Hæmopneumothorax (19 cases).—

X-ray Appearances (sitting position).—Diaphragm high and immobile. Heart displaced to sound side. Opacity of lung area, surmounted by a clear area, the junction being marked by a sharp horizontal line. Splashing sometimes seen at the gas-fluid junction.

Percussion.—POSTERIOR—dullness up to angle or spine of scapula, sometimes surmounted by a tympanitic note. ANTERIOR—skodaic resonance.

Auscultation.—POSTERIOR—weak or absent breath sounds; tubular breathing passing to weak breath sounds in 2 cases; tubular breathing in 3 cases. ANTERIOR—weak breath sounds. Coin sound in 3 cases.

Surgical Emphysema.—Present in 5 cases.

Pyopneumothorax (8 cases).—

X-ray Appearances (sitting position).—Lung area opacity, bounded above by a sharp horizontal line and surmounted by a clear area. Heart displaced to sound side. Diaphragm immobile on affected side.

Percussion.—POSTERIOR—dullness over lower part. ANTERIOR—very variable.

Auscultation.—POSTERIOR—tubular breathing or weak breath sounds. ANTERIOR—tubular breathing or weak breath sounds. (*Note.*—In 3 right-sided pyopneumothorax cases tubular breathing appeared over the left base.)

Pneumothorax (7 cases).—

X-ray Appearances.—Outline of collapsed lung visible. Unusually clear area lateral to lung and above diaphragm, with absence of lung mottling. Serous effusion soon appears. Adhesion of lung to injured portion of thoracic wall prevents complete collapse of lung. Heart displaced to opposite side.

Percussion.—POSTERIOR—tympanitic. ANTERIOR—tympanitic.

Auscultation.—Coin sound. Tubular breathing (amphoric in cases of open pneumothorax).

Surgical Emphysema.—Present.

Collapse (15 cases: left 12, right 3; contralateral 10, homolateral 5).—

X-ray Appearances.—Opacity of lower part or whole of one lung area, with retraction of heart to opaque side. Diaphragm on affected side high and usually immobile.

Percussion.—POSTERIOR—dullness.

Auscultation.—Tubular breathing or weak breath sounds. Occasionally râles or rhonchi.

Rapid recovery. Slight fever. History of having lain on the unwounded side for a period subsequent to injury. Increased area of cardiac pulsation with left-sided collapse.

PARTICULARS OF CASES.

Case 1.—**Copious right hæmothorax and its appearance after the removal of 1500 c.c. of fluid.**

Oct. 6, 1916.—Penetrating wound of the right side of the chest.

Oct. 10. Physical examination: *Right anterior*—diminished vocal fremitus; dullness; tubular breathing. *Right posterior*—diminished vocal fremitus; dullness; weak breath sounds.

Radiogram (*Fig.* 276). Heart displaced to the left; opacity of the whole right lung area.

On Oct. 17, 1500 c.c. of bloody fluid were aspirated from the right pleural cavity.

Oct. 18. Physical examination: *Right anterior*—percussion note higher pitched and

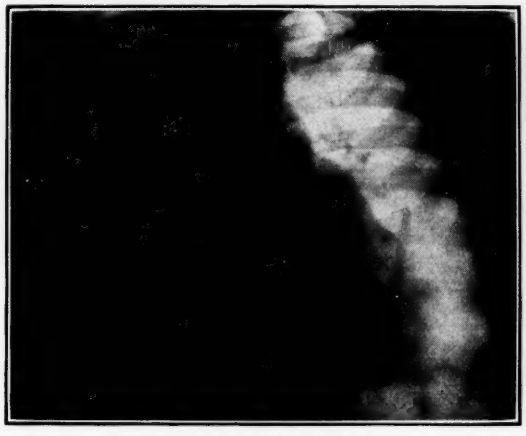

FIG. 276.—*Case* 1, Oct. 10.

FIG. 277.—*Case* 1, Oct. 18.

more tympanitic than on the left side (sitting); absent breath sounds. *Right posterior*—vocal fremitus diminished below the scapula; dullness below mid-scapula; breath sounds absent.

Radiogram (*Fig.* 277). Sitting position. Heart has moved 2 cm. to the right since the previous examination; horizontal gas-fluid junction in right lung area; the lung apex can be seen above the level of the fluid.

Case 2.—**Perforation of the right chest with gradual development of a pyopneumothorax.**

Aug. 22, 1916.—Entry wound 3 cm. to the right of the spine and 17·5 cm. above the iliac crest. Exit wound in the right mid-axillary line 1 cm. below the level of the nipple. Weak breath sounds over the right base.

Radiogram (*Fig.* 278). A small quantity of fluid in the right pleural cavity.

Aug. 27. *Right posterior*—dullness; diminished vocal fremitus; pectoriloquy and faint tubular breathing below the level of the spine of the scapula; apex beat in the nipple line and in the fourth interspace.

Radiogram (*Fig.* 279). Plate in the sitting position shows opacity of the whole right lung area, with some displacement of the heart to the left. In the region of the first and second interchondral spaces the opacity shows increased density, and this darker area is limited above by a horizontal line or gas-fluid junction.

On Aug. 29, a needle passed through the posterior wall of the right chest at the level of the gas-fluid junction revealed the presence of gas and bloody

fluid; 30 c.c. were withdrawn. On Aug. 31, 700 c.c. of infected bloody fluid and some gas were aspirated from the right pleural cavity. Sept. 3. Rib resection and drainage of the right pleural cavity.

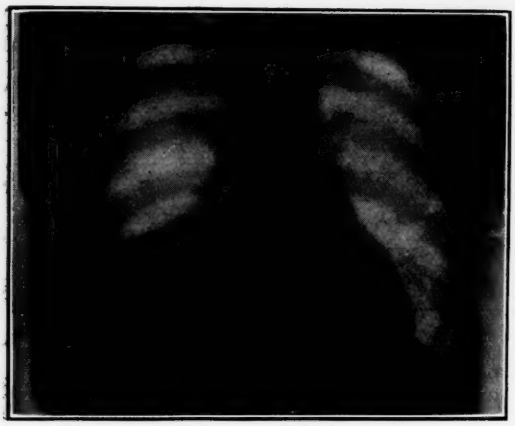

FIG. 278.—*Case* 2, Aug. 22.

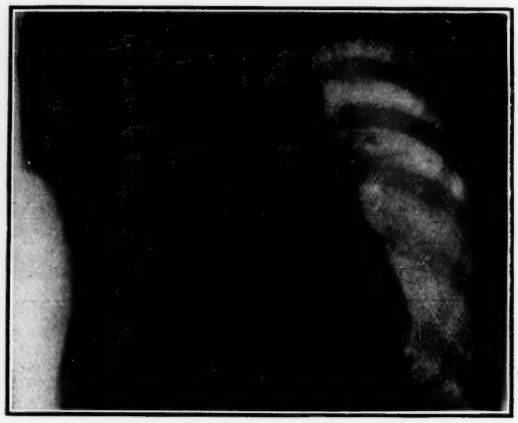

FIG. 279.—*Case* 2, Aug. 27.

Case 3.—**Rapid recovery from a hæmopneumothorax, the result of a bayonet wound.**

Oct. 20, 1915.—The patient received numerous bayonet wounds of the trunk and extremities, and one of these wounds perforated the left anterior thoracic wall.

Oct. 23. Physical examination: *Left anterior* (lying position)—hyper-resonance; loss of breath sounds; metallic tinkling and coin sound. *Left posterior* (sitting position)—dullness over the lower part and loss of breath sounds.

FIG. 280.—*Case* 3, Oct. 23.

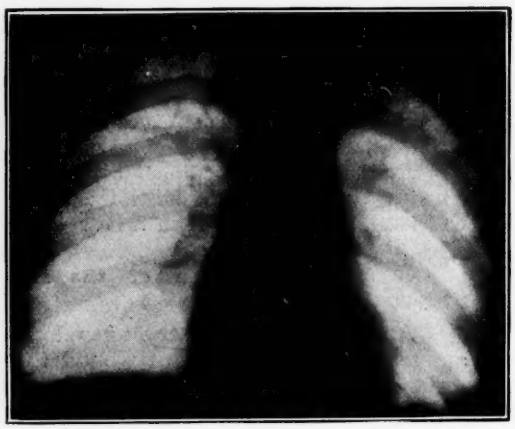

FIG. 281.—*Case* 3, Nov. 8.

Radiogram (*Fig.* 280). Screen examination in the sitting position showed dense opacity in the lower two-thirds of the left lung area, limited above by a gas-fluid junction. The surface of the fluid showed splashing. On Nov. 8, a second *x*-ray examination (*Fig.* 281) shows that the thorax is now normal.

This case is interesting on account of the rapid return to the normal. No exploratory puncture was made and no fluid was withdrawn.

Case 4.—**Hæmothorax becoming a hæmopneumothorax.**

Multiple wounds were received on the posterior aspect of the left shoulder.

Aug. 21, 1916.—Physical examination: *Left anterior*—skodaic resonance. *Left posterior*—dullness and tubular breathing over the lower part.

Radiogram (sitting) (*Fig.* 282). Heart displaced to the right, opacity of the left lung area extending as high as the third costal cartilage.

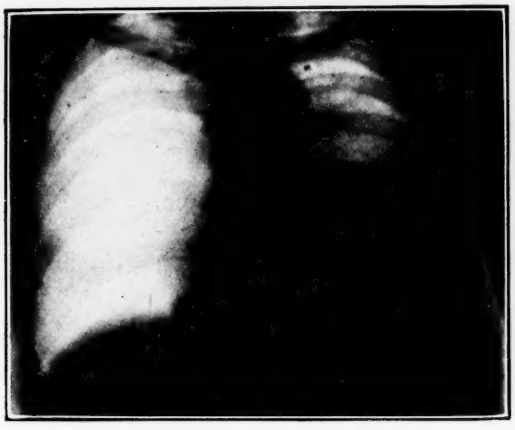

FIG. 282.—*Case* 4, Aug. 21.]

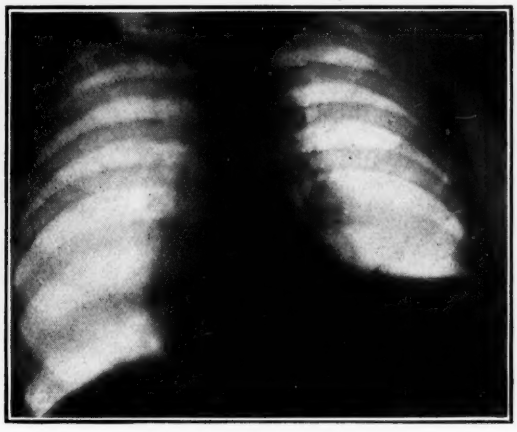

FIG. 283.—*Case* 4, Sept. 4.

Sept. 4. Physical examination: *Left anterior*—percussion note lower pitched than on the right side. *Left posterior*—diminished vocal fremitus; dullness and weak breath sounds over the lower half of the lung.

Radiogram (sitting) (*Fig.* 283). A gas-fluid junction at the level of the fourth costal cartilage; heart displaced to the right.

Case 5.—**Small right hæmothorax developing into a pyopneumothorax.**

The patient received a contour wound of the right side of the thorax some days previous to examination.

Sept. 17, 1916.—A piece of metal has fractured the right seventh and eighth ribs near the angles, during a contour course, and is lying lateral to the inferior angle of the right scapula.

Radiogram (*Fig.* 284). Taken in the sitting position; opacity in lower part of right lung area; heart displaced to the left.

Physical examination: Abdomen rigid; dullness and tubular breathing at the base of the right lung.

FIG. 284.—*Case* 5, Sept. 17.

Sept. 19. Physical examination: Pulse 116; respirations 36; temperature 103°. Apex beat one inch lateral to the nipple and in the fifth space. Both sides move equally in respiration. Abdomen slack. *Right anterior*—percussion note higher pitched than on the left side. *Right posterior*—diminished vocal fremitus; moderate dullness below the level of the

mid-scapula ; weak breath sounds and diminished vocal resonance. *Left posterior*—tubular breathing and pectoriloquy below the level of the inferior angle of the scapula.

Oct. 13. *Radiogram* (sitting) (*Fig.* 285). Gas-fluid junction at the level of the second costal cartilage on the right side ; opacity infero-lateral to this junction. The edge of the partially collapsed upper lobe is visible above the junction. Physical examination : *Right anterior*—diminished expansion ; increased vocal fremitus ;

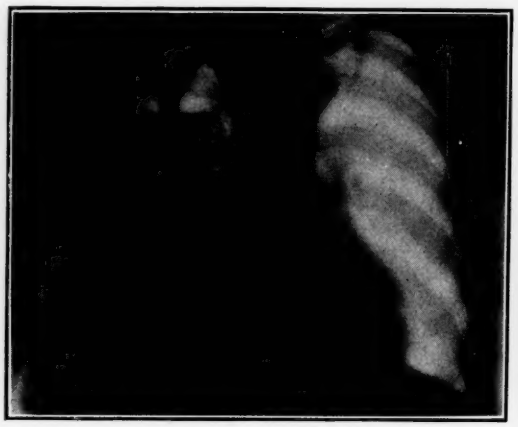

FIG. 285.—*Case* 5, Oct. 13.

FIG. 286.—*Case* 5, Oct. 20.

percussion note higher pitched than on the left. *Right posterior*—dullness ; diminished breath sounds and increased vocal resonance below the level of the inferior angle of the scapula.

Oct. 20. *Radiogram* (sitting) (*Fig.* 286) after drainage of the right pleural cavity. A drainage tube passes into the empyema cavity. The thickened visceral pleura enables one to distinguish the three lobes of the right lung.

Case 6.—**Perforation of the right side of the thorax leading to collapse of the left lung and a right pyopneumothorax.**

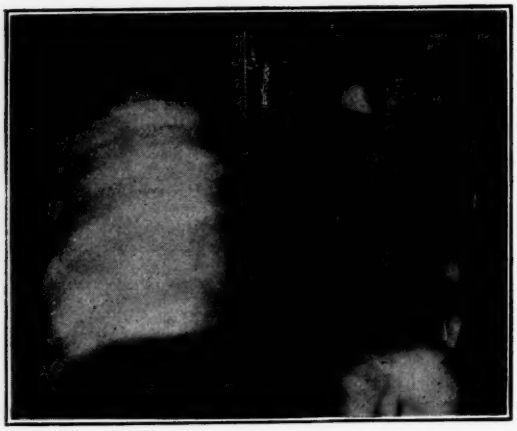

FIG. 287.—*Case* 6, July 16.

July 14, 1916.—Received wounds of the head, leg, and right side of the thorax, and was knocked against the side of the trench so that he became breathless for a few minutes. He then lay on his left side for forty-five minutes.

July 16. Physical examination : Respirations 40. Apex beat in the fourth space half an inch lateral to the nipple. Deficient movement on the left side. Marked cardiac pulsation in the second, third, and fourth left interspaces. Tubular breathing over the left lung anteriorly, and weak breath sounds posteriorly.

Radiogram (sitting) (*Fig.* 287). Heart displaced to the left ; opacity of the lower half of the left lung area. A piece of metal has perforated the right axillary thoracic wall and has given rise to a small pneumothorax in its immediate neighbourhood. The edge of the partially collapsed lung is visible.

July 22 *Radiogram* (sitting) (*Fig.* 288). The left lung opacity has cleared up; there is still displacement of the heart to the left. Gas and fluid are now present in considerable quantity in the right pleural cavity, and there is a double gas-fluid junction, one at the level of the second and one at the level of the third costal cartilage.

July 23. The right pleural cavity was drained, gas and pus escaping. The temperature, which had been high, came down to normal within one week, and remained so for a fortnight, when it began to show nocturnal elevations. A pure culture of *Bacillus perfringens* was obtained from the pus.

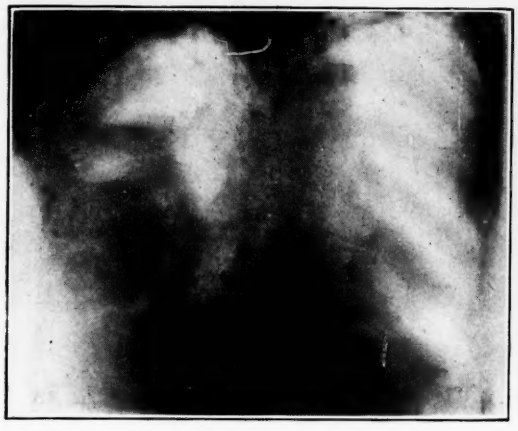

FIG. 288.—*Case* 6, July 22.

FIG. 289.—*Case* 6, Aug. 16.

Aug. 16. *Radiogram* (sitting) (*Fig.* 289). The right lung area shows a partially collapsed lung covered with thickened pleura; lateral to the lung is the drained empyema cavity containing a drainage tube; crossing the lower part of the left lung area is a linear opacity, the nature and origin of which is doubtful. The heart is still somewhat displaced to the left.

The patient was evacuated to England in good condition.

Case 7.— **Right pneumothorax following fracture of ribs, and stages in its recovery.**

July 12, 1916.— Was blown up by a shell and severely bruised without receiving any superficial wound.

July 14. Physical examination: *Right posterior*—surgical emphysema and bell sound over lower half; tubular breathing and pectoriloquy medial to inferior angle of the scapula.

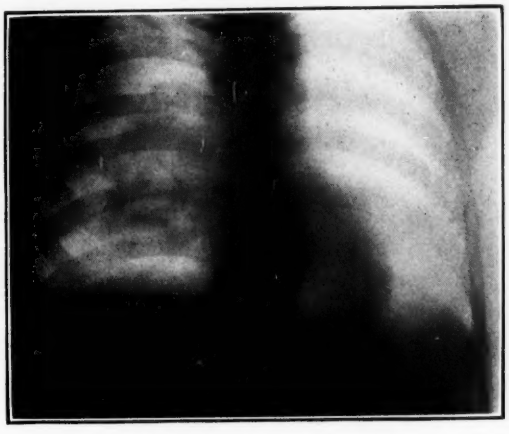

FIG. 290.—*Case* 7, July 14.

Radiogram (lying) (*Fig.* 290). Fracture of the sixth, seventh, and eighth ribs near their angles, on the right side. Collapse of the right lung and displacement of the heart to the left. Right cupola of the diaphragm immobile.

July 25. A *second radiogram* (sitting) (*Fig.* 291) shows a gas-fluid junction and a dense shadow in the cardio-hepatic angle. The heart has returned to the normal position. The pneumothorax has passed into a seropneumothorax.

July 26. Exploratory puncture of the right pleural cavity revealed gas and slightly blood-stained fluid.

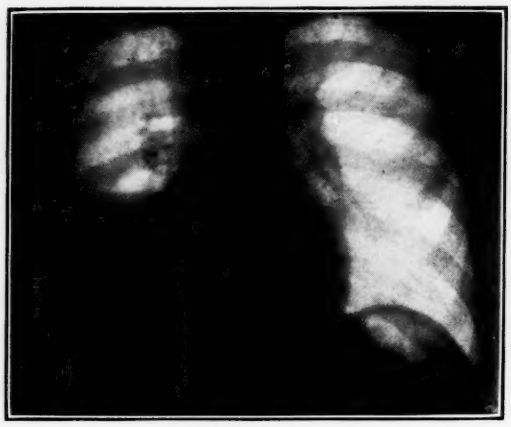

FIG. 291.—*Case* 7, July 25.

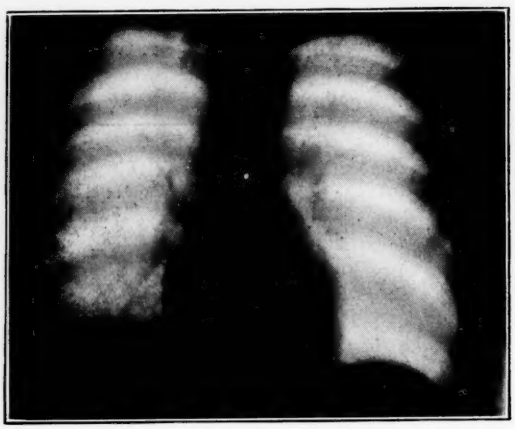

FIG. 292.—*Case* 7, Aug. 2.

A *third radiogram* (sitting) (*Fig.* 292), taken Aug. 2, shows a marked improvement in the appearance of the right side of the chest. There is still a small quantity of fluid in contact with the diaphragm.

Case 8.—**Pyopneumothorax.**

Sept. 16, 1916.—A missile traversed the right side of the chest and emerged some distance below the inferior angle of the scapula.

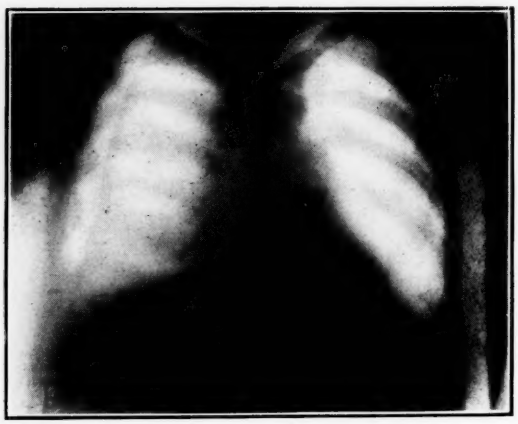

FIG. 293.—*Case* 8, Sept. 24.

Sept. 24. Physical examination: *Anterior*—the apex beat is in the fifth interspace 3 cm. lateral to the nipple. Skodaic resonance on the right side. Harsh loud breathing on the left side. *Posterior*—dullness, pectoriloquy, and well-marked bronchial breathing on both sides, extending up to the inferior angle of the left scapula and the spine of the right scapula. The bronchial breathing is much louder on the left side. Free discharge of pus from the exit wound, which opened into the pleural cavity.

Radiogram (sitting) (*Fig.* 293). Heart displaced to the left. Opacity of the lower part of the right lung area extending up to the level of the fourth costal cartilage. Superior to this the lung can be seen separated from the chest wall by gas.

Oct. 1. *Radiogram* (sitting) (*Fig.* 294). The heart has returned somewhat to the right. The opacity of the right lung area is now surmounted by a gas-fluid

junction at the level of the third costal cartilage. The lung is separated to a greater extent from the chest wall by gas, and there is an excellent demonstration of the partially collapsed lung.

Oct. 3. Rib resection below the inferior angle of the scapula. Pus was only reached on passing a tube upwards for several inches. There appears to have been

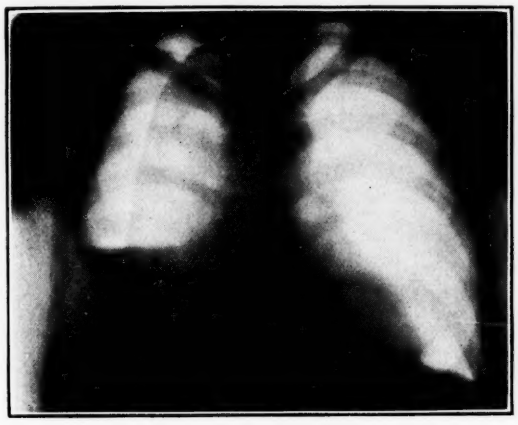

FIG. 294.—*Case* 8, Oct. 1.

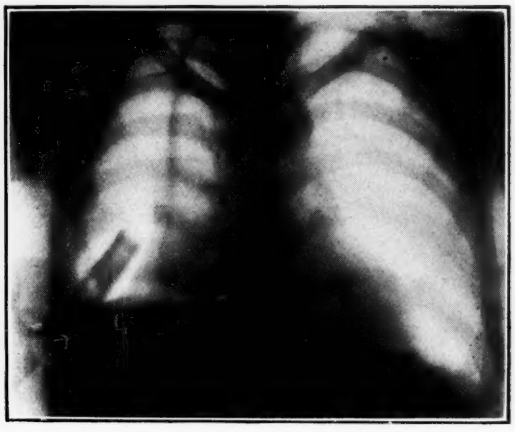

FIG. 295.—*Case* 8, Oct. 16.

loculation of the pleural cavity, the lower loculus being well drained by the exit wound.

Oct. 16. *Radiogram* (sitting) (*Fig.* 295). Stereoscopic plates show adhesion of the right lung to the diaphragm and anterior thoracic wall. The tube is seen entering the pleural cavity, and the fluid level is lower than it was before the rib resection.

The patient was evacuated to England in good condition.

Case 9. — **Contralateral lung collapse following perforating wound of the right side of the thorax.**

Jan. 28, 1916.—A bullet entered the right side of the back, 12·5 cm. to the right of the mid-line and on a level with the first lumbar vertebra. A note from the casualty clearing station states: "Bullet extracted over eighth rib."

Jan. 31. Physical examination: The operation wound is situated over the right tenth costal cartilage. The bullet has probably perforated the diaphragm and liver. *Left anterior*—apex beat in the fourth left interspace 2·5 cm. lateral to the nipple. Skodaic resonance. *Left posterior*—absence of breath sounds in the lower part.

FIG. 296.—*Case* 9, Jan. 31.

Radiogram in the sitting position (*Fig.* 296) shows marked displacement of the heart to the left, and opacity of the whole left lung area. The left cupola of the diaphragm cannot be distinguished. The right lung area is normal. Subsequent *x*-ray examinations showed rapid clearing of the left lung opacity,

a high position of the left cupola of the diaphragm, and a return of the heart to the normal position.

Feb. 1. *Second radiogram* (sitting) (*Fig.* 297). A collection of gas in the stomach and colon demonstrates the high position of the left cupola of the diaphragm. There is still marked opacity of the left lung and retraction of the heart to the left.

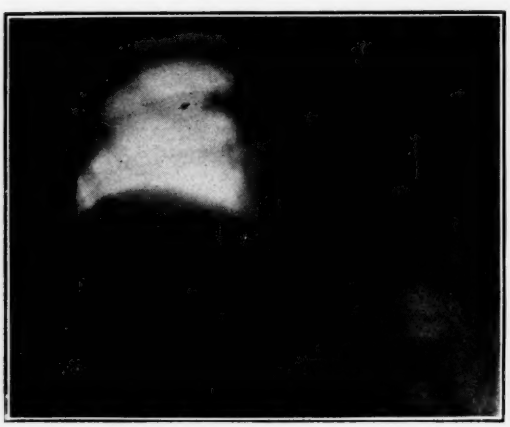

FIG. 297.—*Case* 9, Feb. 1.

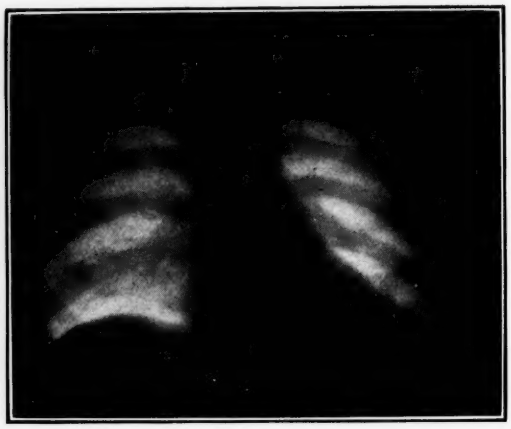

FIG. 298.—*Case* 9, Feb. 14.

Feb. 14. *Final radiogram* (sitting) (*Fig.* 298). The heart is almost normal in position, the left lung opacity has disappeared. A ring of fuse wire marks the nipple.

Case 10.— **Contour wound of the left side of the thorax, producing a contralateral lung collapse.**

March 22, 1916.—Wounded by a shell fragment which entered the left mid-axillary line at the sixth rib, passed downwards and forwards superficial to the ribs, and entered the abdominal wall, where it came to rest at the junction of the left

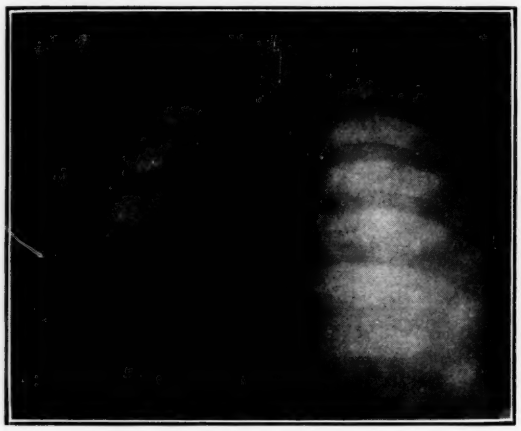

FIG. 299.—*Case* 10, April 2.

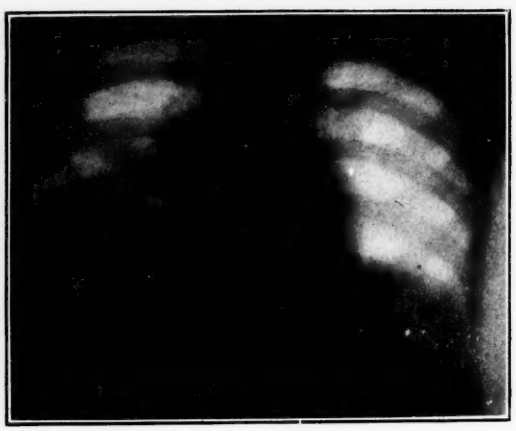

FIG. 300.—*Case* 10, April 15.

lateral and intertubercular planes. Immediately after being wounded the patient lay for some hours on his right side.

April 2. Physical examination: *Right posterior*—diminished vocal fremitus, dullness, and tubular breathing below the level of the spine of the scapula.

Radiogram (*Fig.* 299).—Screen and plate in lying position show marked retraction of the heart and mediastinum to the right, and opacity of the lower third of the right lung. The right cupola of the diaphragm was invisible.

Subsequently an abscess which developed in the abdominal wall was opened, and the metal fragment removed. Four further *x*-ray examinations were made, and revealed a gradual return of the heart to the normal position, and clearing of the right lung area. Owing to the condition of the abdominal wall, all these examinations had to be made in the lying position.

April 15. Fifth *x*-ray examination (*Fig.* 300) shows the heart still somewhat displaced to the right, but otherwise the thorax is normal.

Case 11.—**Superficial wound of the left side of the chest producing a homolateral lung collapse.**

April 11, 1916.—A piece of shell entered the left posterior axillary line, fractured the ninth rib, and rebounded into the extrathoracic tissues superficial to the fifth space in the mid-axillary line. A drainage tube was passed down to the fractured rib.

April 14. Physical examination : Apex beat in the nipple line. *Left anterior*—skodaic resonance and weak breath sounds. *Left posterior*—dullness below the level

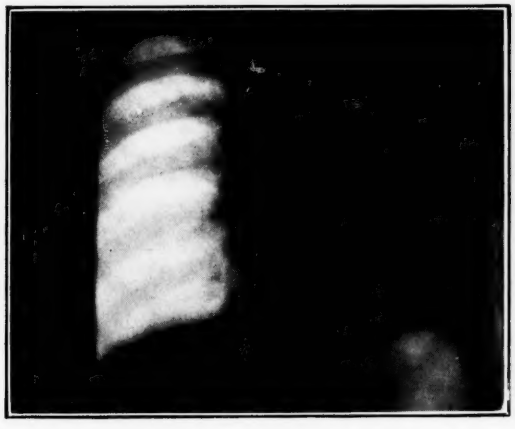

Fig. 301.—*Case* 11, April 14.

Fig. 302.—*Case* 11, April 30.

of the spine of the scapula ; bronchophony in the region of the inferior angle of the scapula.

Radiogram (sitting) (*Fig.* 301). Piece of metal lying in the left lateral thoracic wall superficial to the fifth interspace. Fracture of the upper margin of the left ninth rib in the posterior axillary line. A drainage tube passes into the eighth interspace at the seat of fracture. Opacity of the left lung area. Marked retraction of the heart to the left. Abnormally high position of the left cupola of the diaphragm.

April 19. Coarse rhonchi over the front of the left side of the chest, and tubular breathing over the posterior aspect inferior to the spine of the left scapula.

April 30. *Radiogram* (sitting) (*Fig.* 302). Marked clearing of the left lung area, associated with return of the heart to the normal position.

Case 12.—**Left traumatic infarct associated with a right apical collapse following perforation of the upper part of the left side of the chest.**

A missile entered the left back medial to the vertebral border and at the level of the spine of the scapula. It fractured the second, third, and fourth ribs, and emerged above the centre of the left clavicle. Hæmoptysis on two succeeding days.

Oct. 4, 1916.—A few days after being wounded the condition was as follows : *Anterior*—marked indrawing of the left infraclavicular region during inspiration ; a

higher pitched and less resonant note below the right clavicle ; rhonchi on both sides. *Right posterior*—bronchial breathing above the spine of the scapula.

Radiogram (sitting) (*Fig.* 303). Both cupolæ of the diaphragm move well. Retraction of the superior mediastinum to the right. Fracture of the axillary portions of the left second, third, and fourth ribs, with separation of the fractured ends. Opacity of the left lung apex, extending inferiorly to the level of the first

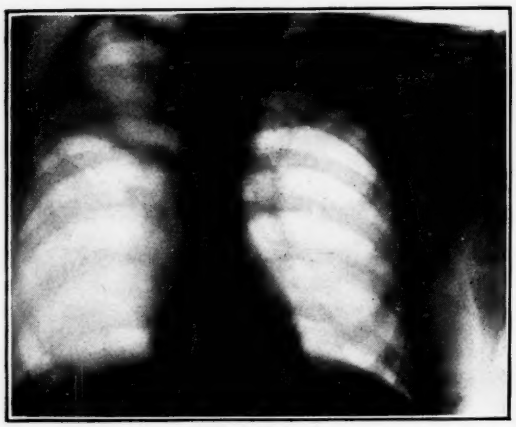

FIG. 303.—*Case* 12, Oct. 4.

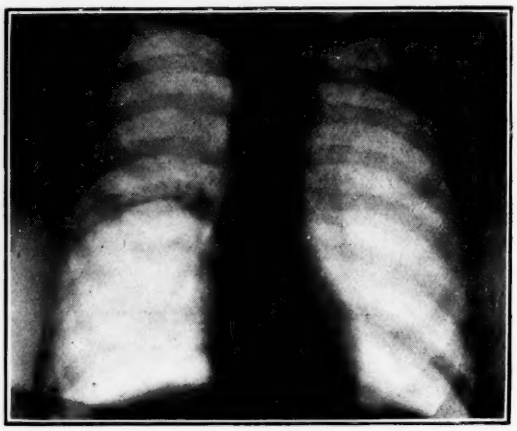

FIG. 304.—*Case* 12, Oct. 18.

interchondral space. Opacity of the right lung apex extending inferiorly to the level of the second interchondral space.

Oct. 12. Physical examination : *Right anterior*—normal. *Left anterior*—diminished expansion, apex beat in the fourth space 2½ inches from the mid-line, higher pitched note. *Left posterior*—dullness and diminished vocal resonance above the spine of the scapula, weak breath sounds above the mid-scapula.

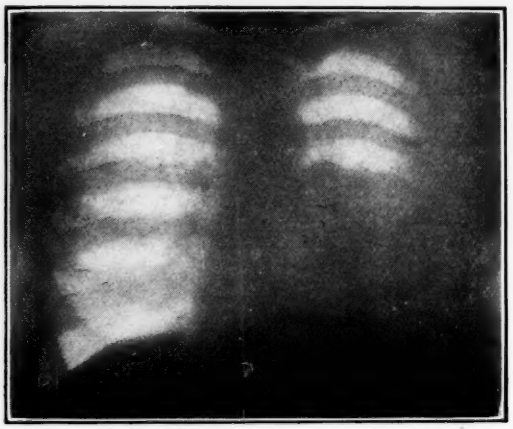

FIG. 305.—*Case* 13, July 7.

Radiogram. Clearing of both lung apices. Superior mediastinum returning to the normal position.

Oct. 18. *Radiogram* (sitting) (*Fig.* 304). Thorax normal apart from the fractured ribs. Physical examination : *Left anterior*—diminished expansion ; diminished vocal fremitus ; low pitched and more tympanitic percussion note ; very weak breath sounds.

Case 13.—**Left basal pneumonia.**

July 3, 1916.—Patient felt out of sorts. July 4, acute pain in the left side ; breathing difficult.

July 7. Physical examination : Temperature 104° ; respirations 40 ; pulse 120. Tubular breathing and coarse crepitations at the left base.

Radiogram (sitting) (*Fig.* 305). Opacity of the lower half of the left lung area ; no displacement of the heart.

July 18. *Second radiogram* (sitting) (*Fig.* 306). Left cupola of the diaphragm somewhat higher than normal; complete clearing of the left lung area.

Note.—This case should be contrasted with lung collapse, where there is always marked displacement of the heart.

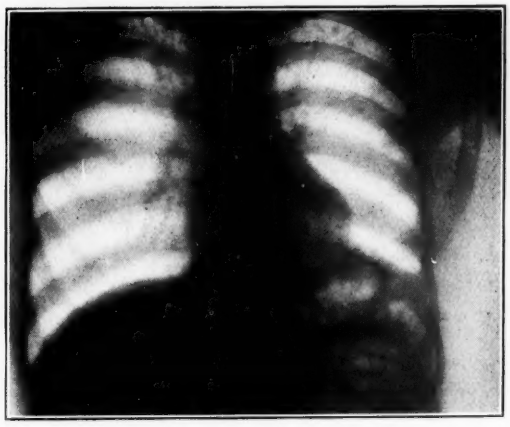

FIG. 306.—*Case* 13, July 18.

***Case* 14.—Perforation of the right side of the chest and subphrenic region resulting in a right empyema and pericarditis. Death.**

Sept. 14, 1916.—Wounded. The missile entered the fifth interspace 2 cm. to the right of the mid-sternum, and emerged 14 cm. to the right of the spine and 10 cm. above the iliac crest. The subsequent post-mortem examination showed that it opened the right pleural and pericardial cavities, traversed the diaphragm, liver, and peritoneal cavity, and emerged through the posterior abdominal wall.

Sept. 18. Physical examination: *Left anterior*—visible pulsation in the second, third, and fourth left interspaces; apex beat in the fifth interspace 7 cm. lateral to the nipple; percussion note higher pitched than on the right side; the stomach note passes up to the fifth interspace in the left mid-axillary line. *Left posterior*—tubular breathing and pectoriloquy extending as high as the inferior angle of the scapula.

Radiogram (sitting) (*Fig.* 307). Right cupola of the diaphragm almost immobile; left cupola of the diaphragm invisible; displacement of the heart to the left.

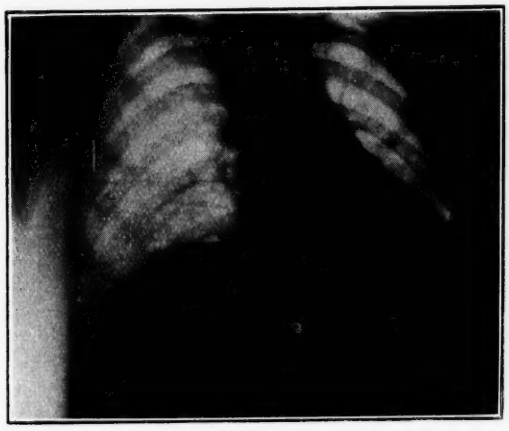

FIG. 307.—*Case* 14, Sept. 18.

FIG. 308.—*Case* 14, Sept. 28.

For nine days the patient improved, the pulse dropping from 104 to 64, the respirations from 32 to 20, and the temperature to 99°.

Sept. 25. Weak breath sounds and râles at both bases; no change in apex beat. Next day sudden acute shooting pain along the track of the missile, and marked elevation in the temperature, pulse rate, and respiration rate.

Sept. 27. 1050 c.c. of sterile serous effusion removed from the right pleural cavity, resulting in relief of the dyspnœa; tubular breathing at both bases; diminished vocal fremitus over the right base.

Sept. 28. *Radiogram* (sitting) (*Fig.* 308). Opacity of the lower two-thirds of the right lung area; marked displacement of the heart to the left.

Sept. 29. From the right pleural cavity 750 c.c. of slightly turbid fluid were removed.

Subsequently the patient seemed to improve. The temperature fell to normal and he felt much better, but on Oct. 9 he died quite suddenly.

Post-mortem.—Pericarditis with effusion; right empyema, with the lung adherent anteriorly, and a small loculation postero-inferiorly; subphrenic adhesions; left lung normal.

Note.—Rib resection and drainage of the right pleural cavity should have been performed.

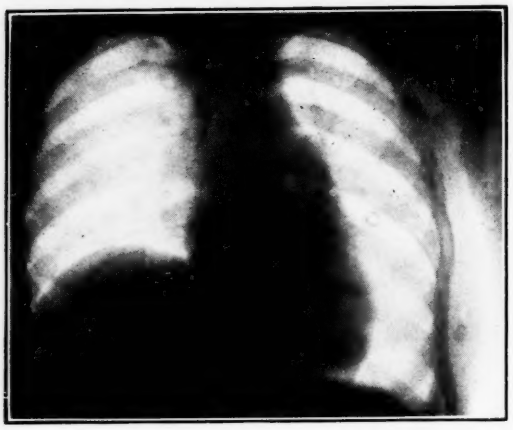

FIG. 309.—*Case* 15.

Case 15.—**Paralysis of all the muscles of respiration except the left half of the diaphragm.**

A shrapnel ball perforated the right sternomastoid muscle at the level of the fifth cervical vertebra, passed obliquely downwards and to the left posterior to the carotid sheath, traversed the neural canal of the seventh cervical vertebra, entered the left thoracic cavity, and came to rest on the visceral aspect of the left third rib, lateral to its neck.

Screen examination showed the right cupola of the diaphragm immobile and in position of full expiration.

Radiogram. A plate taken in the sitting position and at the end of a full inspiration is reproduced (*Fig.* 309). The left nipple is marked by a fuse wire. Note the abnormal difference in level of the two cupolæ of the diaphragm and the peculiar appearance of the heart.

This case is of especial importance in considering the etiology of lung collapse, since we have here a lung retaining its normal *x*-ray appearance when all its muscles of respiration are paralyzed.

There was loss of sensation below the third costal cartilage and paralysis of the right arm, lower extremities, abdominal muscles, and the intercostals.

The patient was evacuated to England, and the further course of the case is unknown.

Case 16.—**Right apical traumatic opacity surrounding a lung perforation.**

A shrapnel ball entered below the junction of the outer and middle thirds of the right clavicle, and was removed from the muscles of the back, one inch to the left of the midline and two inches above the inferior angle of the scapula. The percussion note over the right apex was higher pitched and less resonant, and the breathing was tubular.

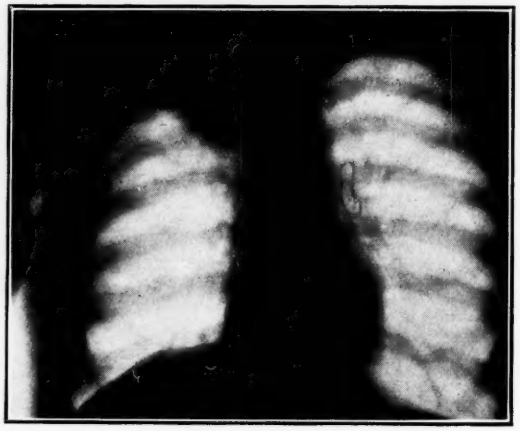

FIG. 310.—*Case* 16.

Radiogram (*Fig.* 310) is reproduced from a plate taken in the sitting position and at the end of a full inspiration. The fuse wire is on the operation wound. Note the opacity at the right apex and the absence of fluid in the pleural cavity. Two weeks intervened between the injury and the *x*-ray examination.

Case 17. — **Accumulation of gas between the right cupola of the diaphragm and the liver.**

Oct. 16, 1915.—Wounded in the cæcal region. An operation was performed in a casualty clearing station, and no perforation of the bowel found. Was admitted to this hospital with a diagnosis of peritonitis and right basal pneumonia.

Signs and Symptoms.—Temperature was of a septic type, being elevated at night and normal in the morning; blood-stained sputum; dullness, tubular breathing, and fine râles at the right base; swelling and tenderness in the epigastrium.

Percussion. — Along the right nipple vertical line one passed from normal lung note to a tympanitic note at the fourth costal cartilage. This was maintained to the costal margin, where it passed into a narrow band of liver dullness.

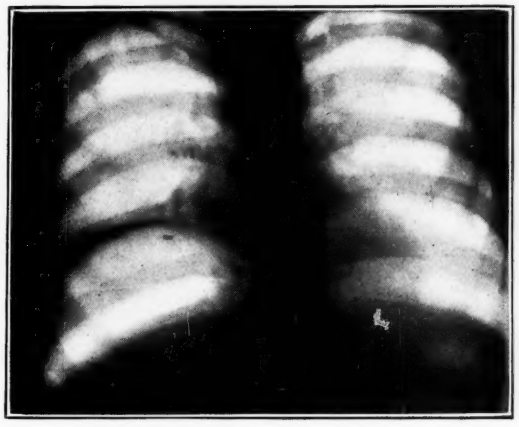

FIG. 311.—*Case* 17, NOV. 6.

Nov. 6, 1915. *Radiogram* (*Fig.* 311). The right cupola of the diaphragm forms a thin opaque septum, convex upwards, between the much diminished right lung area and the large suprahepatic gas-bubble. This gas-bubble extends from the eighth to the tenth rib. Slight respiratory movement was observed in this part of the diaphragm.

Nov. 7. A portion of the tenth rib was removed in the right anterior axillary line by Major Maynard Smith. A large quantity of gas and a little pus were evacuated.

Nov. 9. Discharge of fæces from the operation wound.

Nov. 16. A second radiogram showed a very marked diminution in the size of the right subphrenic gas-bubble. The patient was shortly afterwards evacuated to England in good condition.

Case 18.—**Aneurysm of the ascending arch of the aorta, due to disease.**

FIG. 312.—*Case* 18.

The patient was admitted to the base hospital with the diagnosis of aortic aneurysm.

Physical examination: Apex beat in the fifth space half an inch lateral to the nipple; pulsating area below the right clavicle; weakness of the left radial pulse; right infraclavicular and parasternal area of dullness; systolic and diastolic murmurs at the apex and base.

Radiogram (*Fig.* 312). A large abnormal sharply-defined opaque area projects into the right lung area from the mediastinum. No expansile pulsation could be seen, but the medial portion of the lower border showed slight movement.

Case 19.—**Adhesion of lung to fractured ribs, preventing complete collapse of the lung in a pneumothorax.**

Large gutter wound of the back below the inferior angle of the right scapula.

Sept. 19, 1916.—Physical examination : *Right anterior*—low-pitched and resonant percussion note ; complete absence of breath sounds. *Right posterior*—high-pitched dull percussion note ; no breath sounds.

Radiogram (sitting) (*Fig.* 313). The right cupola of the diaphragm is depressed, and shows slight respiratory movement ; it is surmounted by an abnormally clear area. The heart is displaced to the left. The outline of the partially collapsed right lung is visible, and the following points are demonstrated : (*a*) The lung apex has collapsed by the approximation of the axillary, costal, and mediastinal surfaces ; (*b*) The lung is adherent to the ninth rib in the mid-axillary line ; above this point it has receded medially from the chest wall ; (*c*) The lower part of the lung has shrunk upwards so as to leave a clear gas-containing space between the lung and the diaphragm. Fracture of the right ninth and tenth ribs, lateral to the angles.

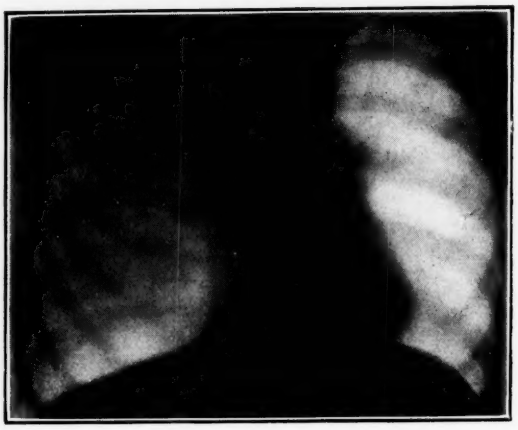

FIG. 313.—*Case* 19.

Case 20.—**Drained empyema showing partial subdivision into two cavities by an adhesion of the lung to the lateral chest wall.**

Admitted to hospital with a septic wound of the left hand and a temperature showing an evening rise to 103°. Cough, sweating, and signs at both lung bases developed. A needle passed into the right posterior axillary line drew off some blood.

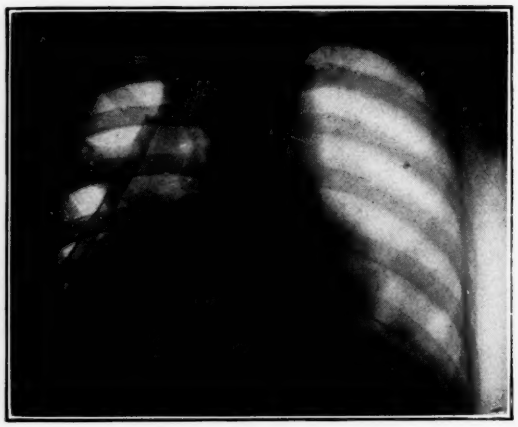

FIG. 314.—*Case* 20, June 9.

April 30, 1916.—*X*-ray examination four weeks after admission into the hospital showed : opacity of the right lung area ; right cupola of the diaphragm invisible ; displacement of the heart to the left.

May 1. Exploratory puncture below the inferior angle of the right scapula revealed pus ; a rib was resected and the right pleural cavity drained.

June 9. *Radiogram* (*Fig.* 314). The right lung is partially collapsed, and leaves a clear space laterally, which is partially separated into upper and lower compartments by an adhesion between the lung and the lateral thoracic wall. The drainage tube passes upwards posterior to this adhesion.

July 26. *X*-ray examination shows no change in the thoracic picture.

Case 21.—**Left empyema in process of recovery.**

Dec. 19, 1915.—Wounded. On admission there were several wounds on the back and buttocks, and air was passing in and out through an opening to the left of the spine and over the ninth rib. Drainage of the left pleural cavity was maintained through this opening for the ensuing two months.

Feb. 17, 1916. *Radiogram* (*Fig.* 315). A large piece of metal in the left pleural cavity, between the diaphragm and the posterior part of the tenth rib. The heart lies almost entirely to the right of the middle line. A few small dense opacities in the right lung area. The lateral margin of the left lung can be faintly seen as it passes vertically upwards from the diaphragm, lateral to the metal fragment, to fuse with the anterior portion of the third rib.

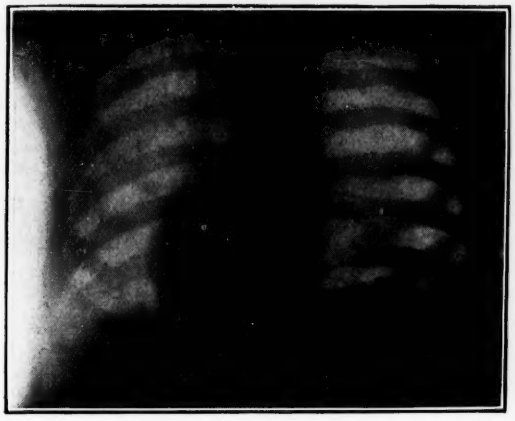

FIG. 315.—*Case* 21, Feb. 17.

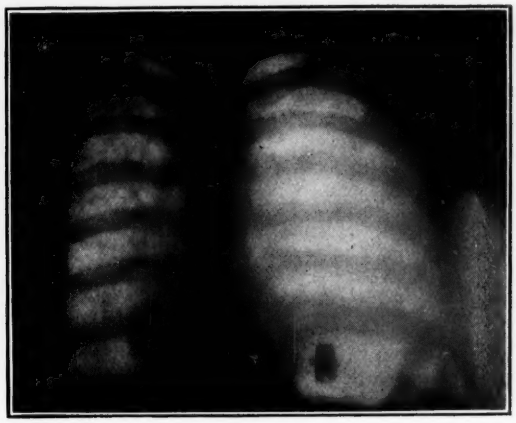

FIG. 316.—*Case* 21, Feb. 24.

Feb. 24. *Second Radiogram* (*Fig.* 316). Since the previous week the heart has returned somewhat to the left side, but is still far from its normal position. The left cupola of the diaphragm is higher than normal, and there is a collection of gas in the stomach and colon. The lateral margin of the left lung is still visible, and has not altered its position. The high position of the left cupola of the diaphragm indicates the return of negative pressure in the left pleural cavity.

Case 22.—**Perforation of the left side of the chest resulting in pyopneumothorax with adhesions. Retraction upwards of the lower lobe of the lung is well demonstrated.**

FIG. 317.—*Case* 22, Oct. 2.

FIG. 318.—*Case* 22, Oct. 16.

Sept. 25, 1916.—A shrapnel ball entered superficial to the sternal end of the left clavicle and half an inch lateral to the sternoclavicular joint. A few days later

the ball was removed from the back, where it lay superficial to the inferior angle of the left scapula.

Oct. 2. Physical examination: Respirations 32; pulse 92; temperature 103°. *Left anterior*—dullness and very weak breath sounds over the first and second interspaces. *Left posterior*—normal.

Radiogram (sitting) (*Fig.* 317). A piece of wire lies embedded in the left lung lateral to the hilus. There is a gas-fluid junction at the level of the second interchondral space. Inferior to this level the left lung area is moderately opaque, with the exception of a supradiaphragmatic triangular clear area. It is probable that the lower lobe has retracted upwards from the diaphragm, leaving its bed to become occupied by gas.

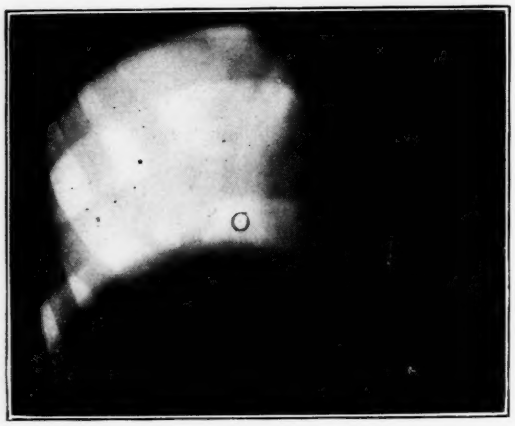

FIG. 319.—*Case* 23.

Oct. 10. Purulent fluid is being discharged through the entry wound. Oct. 16. Temperature normal. Exploratory puncture 6 cm. inferior to the lower angle of the scapula is negative.

Radiogram (sitting) (*Fig.* 318). Impaired movement of the left cupola of the diaphragm. The heart shows some retraction to the left. Marked clearing of the left lung area, with disappearance of gas-fluid junction and a change in the position of the wire, indicating descent of the lower lobe of the lung.

Case 23.—**A large fragment of metal in the right pleural cavity.**

Radiogram (*Fig.* 319). Shows the fragment lying in the right pleural cavity, posterior to the sixth costochondral joint. Removed at a subsequent operation.

Case 24.—**Right hæmothorax, and shrapnel ball in the pericardial cavity.**

A shrapnel ball entered the back 10 cm. to the right of the spine and over the tenth rib, perforated the lower lobe of the right lung, and probably entered the

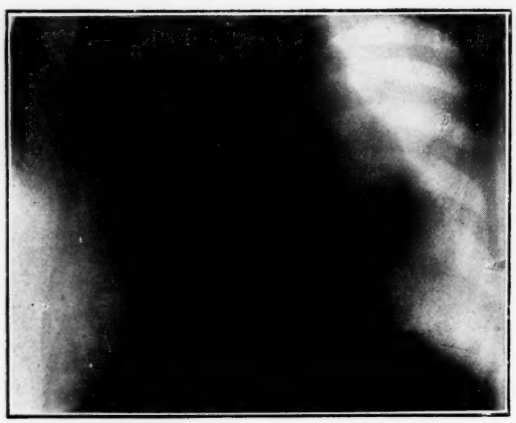

FIG. 320.—*Case* 24, Aug. 22.

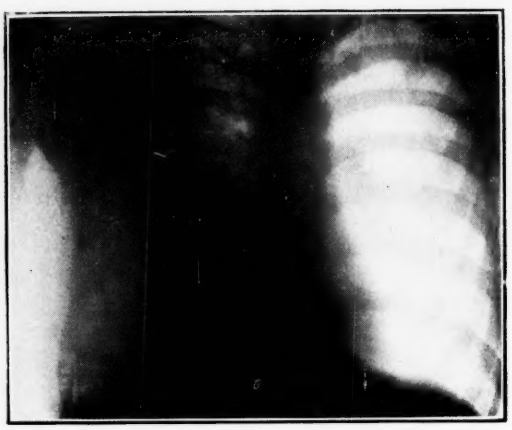

FIG. 321.—*Case* 24, April 20.

pericardial cavity between the œsophagus and the inferior vena cava. It gave rise to a right hæmothorax and pericarditis.

Aug. 22, 1916.—Physical signs *Right posterior*—weak breath sounds and dullness. *Anterior*—apex beat in the sixth space three inches lateral to the nipple; pericardial rub.

Radiogram (sitting) (*Fig.* 320). Opacity of the whole right lung area, with displacement of the heart to the left. Shrapnel ball close to posterior surface of heart. Exploratory puncture of the right pleural cavity revealed sterile bloody fluid.

Sept. 9. Physical signs: *Right posterior*—dullness and weak breath sounds below the spine of the scapula. *Right anterior*—weak breath sounds.

Radiogram (sitting) (*Fig.* 321). The left margin of the heart has moved two inches to the right, and the shrapnel ball has moved with it. Some clearing of the right lung opacity supero-medially.

Case 25.—**Large piece of metal embedded in the left lung. Removed at a subsequent operation.**

Dec., 1916.—The patient was wounded by a piece of shell which entered the back in the middle line and 11 cm. below the inferior angle of the scapula. There was a history of aspiration of blood from the left pleural cavity.

April 20, 1917.—*Radiogram* (sitting) (*Fig.* 322). Showed immobility of the left cupola of the diaphragm, with marked angulation due to adhesion between the

FIG. 322.—*Case* 25, Sept. 9.

diaphragmatic and visceral pleuræ. The lateral portion of the left lung area was somewhat opaque, and a large fragment of shell was embedded in the lung 12 cm. anterior to the posterior skin mark.

A portion of rib was resected antero-inferior to the inferior angle of the left scapula. Sutures were passed with the object of anchoring the lung to the exposed parietal pleura, and some bubbling took place at the upper angle. Subsequently these sutures were found to have been unnecessary, as the parietal and visceral pleuræ were fused into a thick membrane. The pleura and lung were incised, the finger was inserted, and the metal fragment located by palpation. One was impressed with the extreme hardness of the heart, and the friable condition of the lung, which easily enabled the palpating finger to lay bare the foreign body. A pair of forceps, slipped along the finger, completed the extraction. The pleura, muscles, and skin were sutured, and collodion was applied. Apart from slight hæmoptysis and an evening rise of temperature to 100° for five days, there were no subsequent complications. The wound healed by first intention, and the patient was perfectly well at the end of a fortnight.

A skiagram taken two weeks after operation showed no change in the thoracic picture apart from the absence of the foreign body.

Case 26.—**Perforating wound of the right side of the chest.**

This skiagram (*Fig.* 323) was taken two months after the infliction of the wound. The exposure was made during full inspiration, and marked angulation

FIG. 323.—*Case* 26.

of the right cupola of the diaphragm is revealed. This is due to adhesions between the visceral and diaphragmatic pleuræ.

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TWO CASES OF KERATODERMIA BLENNORRHAGICA.

By Captain CRAWFORD LUNDIE, R.A.M.C.

History and Literature.—All the literature consulted credits Vidal with being the first to describe a case of this rare disease in 1893. Sequeira and Turnbull described the first case recorded in England in 1910. Simpson published a very complete article on the subject in the *Journal of the American Association*, Aug. 12, 1912, giving a synopsis of all previously reported cases. Luys refers to monograms by Vidal, Jeanselme, Jacquet, Chauffard, and Le Damany, and quotes the description given by the last named. Watson, of Glasgow, in his treatise published in 1914, refers to a total of some twenty-five cases reported in all literature up to that time. Graham Little described the condition in the *Practitioner*, 1916, and gave a synopsis of thirty-eight previously reported cases. Three cases occurred in a general hospital, and were reported by Captain Brown, R.A.M.C. Two cases have been reported by French authors in *Les Annales des Maladies Vénériennes* of this year—the first by Gougerot and Clara in February, and the second by Montpellier in May. Two cases have occurred in another general hospital.

Description.—The condition is most characteristic on the most common site, viz., the soles of the feet. Here it begins as a small conical protuberance of a pinkish colour, hard to the touch like a corn, and quite painless: further, it may appear while the patient is in bed and not exposed to the conditions producing corns. As it progresses the central cone becomes brownish, but a pink circle persists round the base like the cambium layer in a growing plant. The cone now assumes the appearance of a blister, but when opened is found to contain no fluid, only a pasty mass of epithelial cells. In the later stages, or under treatment, the pink 'growing' circle becomes white, the cone-shaped mass withers, as it were, and drops off, leaving a pink base and no infiltration of the normal skin, so that no permanent scar is left as in syphilides, which are the lesions most likely to be confused with it.

This is the description of the individual lesions as seen in the present two cases, and agrees fairly closely with the descriptions by French writers of what they describe as "nail-like horns" and "dry blisters," according to the stage of the growth of the lesion. Sequeira also gives an apt description when he likens them to "sloes embedded in the skin." When grouped, the lesions exactly correspond to Sequeira's description, "like mountain ranges on a relief map." (*Fig.* 324.)

Pathology.—The gonococcus seems never to have been found in these lesions, but they are invariably accompaniments of gonorrhœa, generally of old standing, and always with blood infection, evidenced in most cases by

arthritis, and often by cachexia. Jacquet, Chauffard, and Fiessinger have worked on the pathology. They failed to inoculate animals or normal men with it, but they succeeded in inoculating a sound piece of skin on the patient himself with skin débris scraped from the lesions. Gougerot and Clara agree with these authors in believing the condition to be a gonococcal, dry, hyperkeratosic pyodermia, whose origin is favoured by a combination of: (1) Suitable terrain; (2) Epidermic maceration (inoculation under a watch-glass); (3) Inoculation with products of keratosic scratching. In the present cases the lesions began in each case on epidermis macerated by a Scott's dressing.

FIG. 324.—A case of keratodermia blennorrhagica.

Treatment.—All the monograms consulted agree that the essential part of the treatment is to cure the general gonorrhœal infection. All but one, that of Gougerot and Clara, recommend no local treatment. Nearly all recommend vaccine treatment. Gougerot and Clara found resorcin dressings useful. Watson recommends urotropine internally. Graham Little says vaccines are the only treatment, and seems to have found them always effectual. So far as the skin condition is concerned, this was not so in Montpellier's case, nor in the first case here, which developed keratosis *while actually having vaccine treatment.*

Case 1.—C——, age 30, was admitted to a general hospital, on Feb. 26, 1917, suffering from acute gonorrhœa of eleven days' duration. He had had gonorrhœa ten years ago. On admission, he had conjunctivitis, and a smear was taken to examine for gonococcus. This was negative, but arthritis of the left ankle developed

next day, proving there was blood infection. The eye condition was probably also an indication of blood infection. He was put on treatment that had proved very satisfactory in many joint cases, viz., sensitized gonococcal vaccine of the strength 100 million per c.c., administered as follows: First day, ¼ c.c.; second day, ½ c.c.; third day, ¾ c.c.; fifth day, 1 c.c.; seventh day, 1½ c.c.; ninth day, 2 c.c.; twelfth day, 2½ c.c.; fifteenth day, 3 c.c.; eighteenth day, 3½ c.c.; twenty-second day, 4 c.c.; twenty-sixth day, 4½ c.c.; etc. Locally, the joint was treated with Scott's dressings.

The joint improved very much on this treatment, and the temperature got less, but the patient complained always of vague muscular pains, which seemed to be an indication of generalized infection. He was also thin from the first, though wasting increased later. On March 15 there appeared what looked like condylomata on the penis, and transfer to the syphilis side was contemplated; but before this was arranged the 'condylomata' had disappeared, and the typical lesions of keratodermia blenorrhagica had appeared on the feet (March 16). They were in the very early stage, and were all pink. As it was judged imprudent to diagnose this rare condition after seeing only one case previously—Captain Brown's first—the other two officers on the staff who had seen that case were asked to examine the patient. After careful consideration, they agreed with the diagnosis. In view of Graham Little's high claims for vaccine treatment, it was rather disconcerting to find a case develop this condition while actually having vaccines.

On the advice of Captain Haworth, who made the vaccine, it was suspended, and when the ankle swelled again it was aspirated to relieve pressure and pain. The fluid, however, seemed to come rather from the tissues than from the joint. Next day the ankle was œdematous, and pitted on pressure, but the urine was free from albumin. Scott's dressing was stopped on March 26, as the skin was getting tender. On March 28 the left knee contained fluid, and 3½ c.c. of vaccine were given to combat this. On March 31 the knee was aspirated and culture attempted in the hope of making an autogenous vaccine. There was no growth. A dose of 4 c.c. of vaccine was given on April 2, and then the course was suspended, as the patient seemed very sensitive to it, as shown by rise of temperature. On April 12, a growth of gonococcus was got from fluid aspirated from the right knee, but the strain could not be established, and again autogenous vaccine was impossible. Another attempt at culture failed, and no further fluid was available, as the joints ceased to accumulate fluid.

Meanwhile the keratosis spread up the legs, and later appeared on hands, arms, and penis. The prostate was almost normal, but in the discharge obtained from it was the diphtheroid bacillus so often found in chronic gleets. By Captain Haworth's advice, therefore, the patient was put on the triple vaccine containing gonococci 50 million, diphtheroid bacilli 100 million, and staphylococci 100 million per c.c. This was given very gradually, at intervals of five or six days, thus: First dose, ¼ c.c.; second dose, ¼ c.c.; third, ½ c.c.; fourth, ½ c.c.; fifth, ¾ c.c.; sixth, ¾ c.c.; and so on. At the same time, he was, by Sir J. Rose Bradford's advice, put in the open air every fine day. A gradual improvement in temperature and general condition set in. The nourishing diet and the tonic of quinine, strychnine, and iron which he had had from the first were continued. Later, Captain Haworth advised another course of sensitized vaccine, as follows: First day, 1 c.c.; fifth day, 2 c.c.; ninth, 4 c.c.; thirteenth, 6 c.c.; and so on, every fourth day, up to 12 c.c. He improved more rapidly on that, and by July 1 his temperature was normal. He was well enough soon after to be evacuated to England; but keratosis was still present, though the joints and general condition were much better. In this he resembled Montpellier's case.

Case 2.—R——, resembled the case of Gougerot and Clara, in that he was not desperately ill, and walked into hospital. He had fluid in his right knee, which he said was traumatic, due to a twist two years ago. It was too like gonorrhœal not to be treated as such, and the left ankle developed arthritis while he was in bed with the right knee. Keratosis developed at the site of a Scott's dressing on the left ankle,

but soon reacted, as did also the joints, to sensitized vaccines, administered according to the last-mentioned method. He said he had had the skin condition before his present attack of gonorrhœa, and denied a previous attack. In this he is again like Gougerot and Clara's case, for their patient also denied ever having had gonorrhœa, although arthritis and stricture proved that he had, as did a hard and nodular prostate in the present case. The temperature was normal throughout.

Gougerot and Clara believe the skin lesion to be absolutely characteristic, and they claim to have diagnosed an old gonorrhœa from a cast in a museum by means of it.

The recurrence of keratosis with a fresh attack of gonorrhœa in the second case agrees with Le Damany's observation that such relapses of keratosis frequently follow fresh gonorrhœal infection.

The first case was also seen by Major McCormac, who confirmed the diagnosis, and by Sir George Makins, whose interest in the case secured the services of an artist to make the coloured drawing which accompanies this paper.

This opportunity is taken of thanking all the officers mentioned for their assistance and interest, and particularly Sir George Makins, at whose special request this paper has been written for publication.

SEPTICÆMIA AS A COMPLICATION OF GUNSHOT WOUNDS, WITH NOTES ON 13 CASES.

By Captain H. M. ANDERSON, R.A.M.C.,
and Captain G. RICHARDSON, R.A.M.C.

In the study of a series of cases of septicæmia occurring as a complication of gunshot wounds, three facts of very great interest present themselves: (1) The diversity of organisms which may produce septicæmia; (2) The diversity of clinical pictures produced by similar organisms circulating in the blood in the living state; (3) The presence of living organisms in the blood accompanied by no serious manifest symptoms.

1. *The diversity of organisms which may produce septicæmia.*—In the series of thirteen cases of which clinical records are appended, the following organisms were found to be present in the blood in the living state: (*a*) Streptococci; (*b*) ***B. Welchii*** (bacilli of gas gangrene); (*c*) ***B. œdematis maligni***; (*d*) Pneumobacilli; (*e*) ***M. tetrageni.***

In two instances the infection was of a mixed nature (***Cases*** **3**, **4**). In these two cases the organism determining the clinical type of the infection was the bacillus of gas gangrene, accompanied in the former by a streptococcus, which predominated, and in the latter by ***M. tetragenus.*** In seven cases a pure streptococcus was found (***Cases*** **5**–**11**). In two further cases (***Cases*** **12**, **13**) the infecting organisms were respectively ***B. œdematis maligni*** and a pneumobacillus. In four instances the bacillus of gas gangrene was found: two were pure cultures (***Cases*** **1**, **2**), and two, as already stated, were mixed with other organisms.

2. *The ability of similar organisms, circulating in the blood in the living state, to produce diverse clinical pictures*, is a characteristic feature of streptococcal infections.

3. *The presence of living organisms in the blood without the production of serious manifest symptoms*, is of great importance. The discovery of this very interesting fact was made during the routine examination of the blood in a series of patients with infected gunshot wounds, many of them cases which at no time gave rise to any apprehension as to their issue, and which, owing to their comparatively innocent nature, aroused no suspicion of their true clinical character. Particularly interesting in this respect is a type of septicæmia produced by the bacillus of gas gangrene, causing a more or less characteristic symptom-complex, mild, as a rule, in its clinical progress, and, in all cases in one series, terminating satisfactorily. This type will be considered at greater length later. The streptococcus, strangely enough, whilst capable of producing the most virulent of infections, may act very mildly. Indeed, its presence in the blood has been found to be compatible with an

almost normal state of health, a rise of temperature, often of modest dimensions, being the only clinical evidence of the infection.

Clinical records, in so far as such have a bearing upon the course of the disease and the treatment adopted, together with a full temperature chart of each case, are appended to the paper. This has been done with a view to permit of the formation of individual opinion, and to relieve the authors from generalizing in the absence of adequate data.

In all, 29 bloods have been examined. In 13, positive results were obtained, a percentage of 44·7. Of these, 11 were pure cultures and 2 were mixed. In the following table the various types of infection are indicated, together with the number of cases of each type :—

Predominating Organism	Accompanying Organisms	Cases
1. *B. perfringens* ..	None	2
	Streptococcus	1
	M. tetragenus	1
2. Streptococcus ..	None	7
3. *B. œdematis maligni*	None	1
4. Pneumobacillus ..	None	1

The predominating organism in each case has been considered as the cause of the disease, a position of secondary importance having been allotted to the accompanying organisms, when present, from a clinical and therapeutic point of view. Whilst the justice of this discrimination may be open to question bacteriologically, it has certainly been upheld clinically. To this generalization *Case* 3 is an exception, streptococci predominating, whilst the disease took on the type of an infection by the bacillus of gas gangrene.

The deaths in all types combined has been 5, an encouragingly low figure. In the following table are indicated the end-results of the 13 cases cited :—

Type of Infection	Cases	Recovered	Died
1. *B. perfringens* ..	4	3	1
2. Streptococcus ..	7	5	2
3. *B. œdematis maligni*	1	—	1
4. Pneumobacillus ..	1	—	1

The fatal issue in the case of *B. perfringens* septicæmia was due to tetanus, which supervened on the twentieth day of the disease. At the time when this complication set in, the temperature had been normal for some days, the general state of health was extremely satisfactory, and the symptoms characteristic of the primary infection had completely disappeared. Similarly, in the one case in which the pneumobacillus was the infecting organism, the

general condition had improved considerably: a copious secondary hæmorrhage produced a fatal issue. In these two cases the hope that the infection had been overcome was firmly established, and the presumption is justifiable that a cure in each would have been realized had not unfortunate complications arisen. Unhappily, however, the evidence of blood examination is lacking.

1. **Septicæmia due to the B. perfringens of Welch.**—Greatest interest attaches to septicæmia produced by the bacillus of gas gangrene (*B. perfringens* of Welch). Of this, three definite clinical types were observed, totally differing in their expression and their method of termination. They are: (*a*) A fulminating type, with an emphysematous gangrene rapidly spreading directly from a local focus, accompanied by hyperpyrexia, profound toxæmia, and a terminal septicæmia; (*b*) A fulminating type, without gas formation locally, and accompanied by a subnormal temperature; (*c*) A mild type, with gas production locally, mild constitutional reaction, and, as a rule, a favourable issue.

a. In the first type there is an emphysematous gangrene rapidly spreading directly from a local focus, a spread of such alarmingly rapid proportions, of so fulminating a character, that one often feels curiously impotent to arrest its progress. We have all witnessed this short-lived clinical drama from time to time, and recall vividly the foul nature of the wound, the extraordinary development of a thin, offensive, dark-brown discharge, often necessitating a two-hourly change of dressings, and the advancing and rapidly increasing edge of crepitation and tympanicity. We recall the drawn and anxious expression of the patient's features, the death-like pallor of the skin, the excessive activity of the sweat glands, the dilated pupils, the distressing air hunger, the hyperpyrexia, the rapid, running pulse, and the alertness of the mental faculties. We are confronted in such cases with a profound toxæmia, complicated in its terminal phases with a septicæmia. Blood examinations have been conducted in four cases of this class. In two they were negative; in a third the bacillus was recovered from the blood; in a fourth a streptococcus was found. Unfortunately the notes on the third case have been mislaid, and one hesitates to rely upon memory for clinical details, except to state that the bacillus was found in a specimen of blood taken a few hours before death. The fourth case, which is included under the streptococcal type, was a rapidly spreading emphysematous gangrene of the arm; a streptococcus was found in a specimen of blood taken immediately before amputation; six days later examination was negative.

b. The second type of septicæmia produced by gas gangrene is as peculiar and interesting as it is rare. A description of a case which we have had in this hospital will suffice to bring out its characteristics:—

Pte. A. was admitted in April, 1916, suffering from a severe gunshot wound of the soft tissues of the right thigh inflicted forty-eight hours previously. Prior to admission the wound had been excised and counter-incisions made for drainage. There was very little discharge, practically no swelling, and no smell. The wound was remarkably free from sloughs; the exposed muscles were pale, dry, and friable. The counter-openings were exactly similar to post-mortem incisions—there was no

reaction whatsoever, no discharge, and the tissues were soft, putty-like, inelastic, and painless. There was no gas. The general state of the patient was remarkable —widely dilated pupils, cold dry skin of a deathly pallor, air hunger calling into action the extraordinary muscles of respiration, a temperature too low to record, a pulse too rapid to count, and a very noticeable placidity of mind and feature. Death supervened within twelve hours.

At the post-mortem, six hours later, gas was found in the spinal cord, on the surface and in the substance of the brain, and in the liver. The picture was that of a hæmorrhage, for which indeed an examination was made on admission.

Unfortunately there is no note of a blood examination having been made.

The type of wound described in this class is one to which we have given the name 'cadaveric.' More concerning its clinical features, progress, and pathology will be said in the discussion of septicæmia produced by the streptococcus.

c. The third type, of which four illustrative cases are given (*Cases* 1–4), in which the bacillus of gas gangrene was found circulating in the blood, is an interesting and distinct pathological entity, differing from the first two very markedly. Such patients appear to be rarely in a serious condition, certainly never so ill as to lead one to suspect the true clinical character of the disease. The wound is usually foul, presenting all the appearances of one grossly infected with *B. perfringens* and the organisms which usually accompany it. There is a foul discharge, copious in amount, and containing bubbles of gas. There are stringy, œdematous sloughs, which leave a bleeding surface on removal. There is a marked reaction of the surrounding parts, with pain, swelling, œdema, and slight crepitation. There may be a spreading cellular gangrene of the subcutaneous tissues. Constitutionally, the patient reacts in a characteristic manner. The skin is warm, dry, and of a peculiar dirty-yellow colour, and there is a slight icteric tinge of the conjunctivæ. The tongue is dry and furred, and the breath is foul. The appetite is gone, thirst is never troublesome, and the bowels are confined. Temperature and pulse are slightly raised. Mentally, such patients are typical: they are heavy, stupid, and somnolent. This state of torpidity of mind and function lasts until the blood is sterile, the healing of the wound in the meantime being in no way adversely influenced. In the four cases described, no apprehension as to the issue arose, and nothing beyond the usual wound treatment was called for. The recovery from the infection is gradual, although its entire duration, provided the source of absorption receives adequate attention, is short-lived.

One is justified in assuming that many cases of the kind escape detection because of the mild nature of the infection. Moreover, it would appear that during the course of acute infection in the wound such a complication may supervene and be rapidly overcome. Although such an assertion cannot be substantiated by clinical records, one has frequently noticed during the acute stage of a wound the establishment of a general state such as is described above, lasting for a day or two, and then subsiding. The belief that this may be the case receives support from the fact that during these intermissions there is a recrudescence of wound infection. The bacteriology of the discharge and of the blood in this type of septicæmia is indicated in the accompanying table (pp. 402, 403). Metastasis has not been observed.

2. **Septicæmia due to the Streptococcus.**—In our series of cases the streptococcus has been found in the blood in 53·8 per cent. As a rule it appears in pure culture. In one instance (*Case* 3) it was mixed in preponderating numbers with the bacillus of gas gangrene, but the clinical expression of the infection resembled more the *B. perfringens* type. For this reason this case has been included in the previous class, although one cannot overlook the possible extent to which it was influenced by the presence of a streptococcus.

Streptococcal septicæmia presents many interesting features. One has been in the habit of looking upon an infection of this nature as exceedingly serious, placing the life of the patient in extreme jeopardy. Whilst this may be the case, it is by no means always so. In fact, the infection may be—one might almost say is generally—mild, running a benign course, and often terminates favourably without the employment of any special measures directed to its subjugation. It would appear that a blood infection by this organism may arise during the clinical course of wound suppuration, evidence itself in the mildest of fashions, and then subside without seriously affecting the progress of the case. That this can happen is capable of clinical proof; but in what percentage of cases it really occurs requires further investigation. Inclination towards the belief that it is frequent is very strong, and there is a decided temptation to suggest that many temperatures for which no cause can be found locally in the wound may be explained by a blood examination. So much has one the courage of one's convictions, that the blood of all cases in which no satisfactory explanation for temperature disturbance is discovered, is subjected to a cultural investigation.

Another interesting feature of septicæmia in general, although it has been most clearly demonstrated in the streptococcal type, is the nature and extent of the focus of absorption. Naturally one would anticipate, and correctly so, a greater liability to blood infection the more serious the wound and the less the resisting power of the patient. Nevertheless, the focus may be extremely small and apparently trivial. In one instance, for example (*Case* 10), there were two wounds in the thigh, each no larger than a florin, and extending just through the deep fascia into the superficial layers of the subjacent muscle: wounds in which the drainage was perfect, in which there was no retention of discharge, and in which the infection was of a mild nature. In two others (*Cases* 7, 8) the wounds were also of a slight nature, yet a fulminating and rapidly fatal streptococcæmia supervened.

The measure of the resisting power of the patient, apart from all other conditions, appears to be an important factor. This may be naturally low, or may have been reduced by exposure and privation. In several of our cases there is a history of 'lying out' for periods extending from two to ten days, periods during which the patients were deprived of the ordinary means of sustenance.

It has been possible, from a clinical aspect, to classify into three distinct types the seven cases of streptococcal septicæmia we have had, individual examples of each resembling one another very closely, and differing only in detail. These may be stated as follows: (*a*) An acute type, characterized by hyperpyrexia and delirium, rapid in its progress, and ending fatally;

examples of this type are *Cases* 7 and 8. (*b*) A chronic type, with elevation of temperature, profound anæmia, and great emaciation, running a protracted course, and terminating favourably; *Cases* 5 and 6 are examples. (*c*) A mild type, with few clinical manifestations; *Cases* 9 and 10 are instances.

a. The acute type, of which two examples are given, presented as its most noticeable features delirium and hyperpyrexia. Delirium in the former case was of the muttering type; hysterical in the latter. In both it lasted for the duration of the disease. There was a marked tendency to diarrhœa; loss of weight was not observed until during the closing days. In neither were the wounds grossly infected; they were superficial, thoroughly drained, and pursued an eminently satisfactory clinical course. The process of healing was in no way interfered with. In the notes of one, the clinical report was briefly stated thus: "Wound almost healed; patient dying." Both developed extra-articular metastasis, chiefly of the abortive type. In one there was an embolus of the choroidal vessels. Treatment, which will be dealt with later, was of no avail.

b. The chronic type, characterized by profound anæmia and progressive emaciation, is of very great interest. The course of the disease in the two examples cited was very protracted. In contradistinction to those of the acute type, one observed a moderate disturbance of temperature, entire absence of delirium, freedom from metastasis, and the very marked influence the general infection seemed to have upon the progress of the wounds. Anæmia is profound, and emaciation extreme. Diarrhœa may be troublesome. Whilst there is little tendency to metastasis, there is a decided proclivity to abscess formation in relation to the wounds, should they be multiple.

The appearance of the wounds in this type of streptococcæmia is remarkable. We have described them as 'cadaveric.' This description applies equally well to the general condition of the patient, which, so far as reparative processes are concerned, is inert. The original wound in this stage is, as a rule, extremely dirty, being covered with grey, stringy, sloughing material which is but loosely attached and does not leave a bleeding surface on removal. There is considerable involvement of fascia where this is exposed, necrosis of this tissue often extending far beyond the limits of the wound. The structures around are peculiarly soft, putty-like, and inelastic. There is an entire absence of reaction. The absence of pain is a prominent feature; such wounds can be manipulated in quite a gross fashion without any response on the part of the patient. Where excision or counter-incisions have been practised, probably some days before, the appearance is such as is observed in an incision in a cadaver. One has the impression that the incision has just been made. There is, however, no evidence of there having been any oozing; the skin is soft and doughy, and the muscles are pale and dry, the individual fasciculi standing out plainly. Where sloughs are present, there is a moderate amount of a thick, foul discharge. Once these have been cut away, the discharge ceases, and the exposed tissues remain absolutely inert.

This stage may last days—or weeks, as in *Case* 6, where the duration was one month: on Feb. 10 the wounds of this patient resembled in detail their condition on Jan. 10; not a single granulation was to be seen. During this

time there was a tendency to a slow necrosis of tissues badly supplied with blood, such as tendons and fascial coverings of muscles. There was, moreover, in the case of small penetrating wounds, a proclivity to abscess-formation. These abscesses were peculiar, in that they were not painful and that their contents were under very low tension. The walls of such cavities were the unchanged tissues, which had been pushed aside to make room for the accumulating pus. In their depths one perceived muscle bellies pale and inert, standing out as if they had been dissected. Drainage proved unnecessary, as, after evacuation, no further discharge took place, the walls approximating themselves, but exhibiting no tendency to unite.

Resolution in such wounds, when it does take place, may do so with surprising suddenness and rapidity, complete healing being established in a short time. This change is synchronous with an amelioration in the constitutional state, which, in the meantime, has been one of profound anæmia, progressive emaciation, and apathy.

The cadaveric type of wound is not peculiar to streptococcæmia. It has been observed in other forms of septicæmia and toxæmia. It has been referred to in the *B. perfringens* type. It must be looked upon as an arrest of the process of healing, resulting from a profound degree of infection.

The general bacterial wound flora is, as a rule, fairly consistent. We find streptococci, staphylococci, *B. pyocyaneus*, and diphtheroids. The last are the most interesting, and frequently form the predominating organism, especially in wounds about the lower extremities. They are indistinguishable from involution forms of the true Klebs-Löffler bacillus. They are curved, have bulbous ends, and show segmentation of the body. Some exhibit distinct beading, and all stain with Gram. In only one instance has a diphtheroid been encountered which stained with Neisser. These organisms appear to be saprophytic in character. They are rapidly overcome in culture by others present, so that on first subculture it is unusual to find any. Up to the present we have been unable to isolate these organisms in pure culture. When the wound passes from the cadaveric to the healing stage, the diphtheroids at once disappear.

The condition of the pus cells in cadaveric wounds is sometimes interesting. In the majority of cases the cells show degenerative changes, with fragmentation of the nuclei and vacuolation of the cytoplasm. Rarely they are exceedingly well formed, with the perfection of the normal polymorphs of the blood. Phagocytosis is slight or absent. In one instance, however, the pus cells were packed with organisms, resembling the appearance seen in gonococcal pus. In the healing stage of these wounds phagocytosis is extraordinarily active.

c. In the mild type of streptococcal septicæmia there is very little departure from the normal state of health. Sleep is undisturbed, the appetite is excellent, and the general state remains satisfactory. It may be hard to find any clinical manifestations of the disease, beyond a disturbance of temperature. This, however, may be considerable, reaching 102° or 103° at night. Although it may be continued for some time, it appears to have little effect on the patient. Amongst other symptoms, one has noticed during the course of the disease a slight degree of emaciation, periodic attacks of diarrhœa of

short duration, drowsiness, and, in one case, very mild delirium lasting two days. The healing of the wounds may or may not be influenced; there may be a tendency to retardation. The disease has, therefore, certain resemblances to the chronic type above described, of which it may be considered a mild form.

Two examples of this mild type are given, *Cases* 9 and 10. The former is rather interesting. There were multiple shrapnel wounds involving seven joints: both shoulders, both elbows, both wrists, and the right ankle. On admission, all the wounds were in a perfectly satisfactory state and all in an advanced state of repair. A continued temperature led to examination of the blood, in which a long streptococcus was found in pure culture. The subsequent progress was uneventful, no special measures to combat the septicæmia being called for. It is exceedingly interesting to note that this patient, during the whole period of blood infection, ate well, slept well, and always felt in the best of condition.

The latter case (*Case* 10) is exceedingly interesting. Although the patient is still under observation in this hospital, the progress of the disease up to the present is sufficient to reveal the fact that during the period of wound infection there may be periodic absorption of the streptococcus into the blood. The patient in question was wounded on April 27, 1917. Upon admission, May 3, one noticed slight anæmia and pronounced drowsiness. The wounds had a very inoffensive appearance, and did not exceed an inch and a half in their longest diameter, extending for a short distance into the muscles of the thigh. They were discharging a moderate amount of thick yellow pus, drainage was free, and the tissues around were soft and painless. Such granulations as had formed were rather pale and œdematous. The Carrel treatment had been employed prior to admission. The temperature was 97°. On May 6 it rose to 103°, and on the following day to 103·8°, becoming normal again on May 11. During this interval a streptococcus was isolated from the blood. The patient was uncomplaining during this interval; he ate well, and felt well. There was a tendency to drowsiness, and on the night of May 6, when the temperature was 103·8°, he had mild delirium. On May 13 the blood was sterile. The after-progress is interesting: For six days he appeared to be in a normal state of health. On May 17 the thermometer again registered 103°, drowsiness recurred, and on the following day a streptococcus was again isolated from the blood. He has had one attack of diarrhœa. At the time of writing, May 25, the general state of his health is satisfactory. His wounds were thoroughly explored, but no cause for the re-absorption could be discovered. All possible sources of infection have been investigated and found negative. One must at present, therefore, conclude that the initial focus of the infection was the wound. The case is interesting, in so far as it may, upon investigation, throw some light upon unexplainable temperatures occurring during the clinical progress of a wound.

3. **Septicæmia due to the Bacillus of Malignant Œdema.**—This has been extremely rare. We frequently meet with wounds in which the bacillus is present, often in very considerable numbers, but only in one instance (*Case* 12) has it been found in the blood. This case was rapidly fatal, death

occurring about twelve hours after admission. There were several small penetrating wounds in the posterior aspect of both thighs, discharging a very foul and copious, thin, blackish-brown fluid. The wounds were covered with coal-black adherent sloughs. On admission, gangrene had commenced in the left foot; before death it had reached half way up both thighs. From the discharge the bacillus of malignant œdema, the bacillus of gas gangrene, and a streptococcus were grown. The blood for cultural examination was withdrawn six hours before death. The temperature, which was 102° on admission, became subnormal four hours later, and remained so until the close. At no time was the pulse countable. Up to within a few minutes of death there was a most remarkable lucidity of mind. The patient became sensible of his approaching dissolution, and insisted upon writing to his wife. This he did, two hours before he died. Post mortem, there was extensive gangrene of the muscles of the lower extremities, intense inflammation of the walls of the larger arteries, and widespread venous thrombosis.

A second case, not mentioned in the series, might be included here. It was that of a patient with a very extensive wound of the thigh, of a typically cadaveric nature, from which the bacillus of malignant œdema was grown in almost pure culture. He had symptoms of an intense toxæmia. Examination of the blood was negative. Death occurred at the end of four days. Profound anæmia and rapid emaciation, with a subnormal temperature, were the most pronounced clinical manifestations. Delirium was not present until a few hours before death.

4. **Septicæmia due to the Pneumobacillus.**—This case (*Case* 13) is rather unique. There was a perforating wound of the thigh, with a fracture of the ramus of the pubis. The wound was foully infected, and contained the bacillus of gas gangrene in very large numbers. The patient was profoundly anæmic on admission, although he had not lost much blood. During the whole course of the disease the temperature remained elevated. Syncopal attacks were frequent, and at all times the patient complained of great weakness. The slightest exertion caused most alarming symptoms. Two or three days before death, which followed rupture of an artery, the general condition of the patient had improved considerably, and one had very strong hope of a favourable issue. Although unsupported by cultural proof, it is justifiable to assume that in this case the infection had been overcome before death occurred.

TREATMENT.

Treatment naturally divides itself into local and general. It is unnecessary to indicate what is necessary for the local focus. The ordinary principles of wound technique—the removal of sloughs, the opening up of tracks, and the institution of thorough drainage—are obviously called for. In the case of cadaveric wounds, nothing seems to be of any avail; the treatment of the local condition is that of the general state. One word of caution, perhaps, should be given. Such wounds must be kept moist, in view of their natural dryness. If permitted to become desiccated, large areas of necrosis are the result.

TABLE OF CASES OF SEPTICÆMIA.

Case No.	Blood Culture	Blood Count			Pus from Wound	Metastasis	Result
	1. B. PERFRINGENS TYPE.			per cent			
1	18.11.16. *B. perfringens*, with hæmolysis 27.11.16. Sterile	R.B.C. 3,480,000 Hb. 75 per cent W.B.C. 16,800	Polymorphonuclears Lymphocytes, large ,, small	78·8 7·4 13·7	Streptococci Staphylococci *B. perfringens*	Nil	Cured
2	16.11.16. *B. perfringens*, with hæmolysis and gas 30.11.16. Sterile	R.B.C. 3,160,000 Hb. 60 per cent W.B.C. 15,600	Polymorphonuclears Lymphocytes, large ,, small	71·6 9·4 18·8	Streptococci Staphylococci *B. pyocyaneus* *B. perfringens*	Nil	Cured
3	25.10.16. *B. perfringens* and streptococci 6.11.16. Sterile	R.B.C. 2,280,000 Hb. 55 per cent W.B.C. 15,600	Polymorphonuclears Lymphocytes, large ,, small Eosinophils	73·5 12·0 14.0 0.5	Streptococci *B. perfringens* *B. Hibler IX*	Nil	Cured
4	9.11.16. *B. perfringens* and *M. tetragenus*, with gas and gelatinization of medium	R.B.C. 3,200,000 Hb. 55 per cent W.B.C. 11,000	Polymorphonuclears Lymphocytes, large ,, small Eosinophils	79.0 10.0 10.0 1.0	Streptococci Staphylococci *B. pyocyaneus* *B. perfringens* *B. Hibler IX* *B. œdematis maligni*	Nil	Septicæmia cured. Died of tetanus.
	2. STREPTOCOCCUS TYPE.						
5	25.9.16. Sterile 6.10.16. *Str. longus* 27.10.16. Sterile	R.B.C. 3,080,000 Hb. 60 per cent W.B.C. 12,200	Polymorphonuclears Lymphocytes, large ,, small Eosinophils	72.0 9.0 18.0 1.0	Streptococci Staphylococci	Pus in left hip-joint	Cured
6	16.1.17. *Str, longus*, with hæmolysis 2.2.17. Sterile	R.B.C. 3,200,000 Hb. 65 per cent W.B.C. 12,000	Polymorphonuclears Lymphocytes, large ,, small Eosinophils	79.2 8.2 11.8 0·5	Streptococci *B. pyocyaneus*	Nil	Cured

6	16.1.17. *Str. longus*, with hæmolysis 2.2.17. Sterile	R.B.C. 3,200,000 Hb. 65 per cent W.B.C. 12,000	Polymorphonuclears 79.2 Lymphocytes, large 8.2 „ small 11.8 Eosinophils 0·5	Streptococci *B. pyocyaneus*	Nil	Cured
7	28.10.16. *Str. longus* 5.11.16. *Str. longus*	R.B.C. 2,620,000 Hb. 50 per cent W.B.C. 10,800	Polymorphonuclears 77·2 Lymphocytes, large 7·8 „ small 14·2	Streptococci Staphylococci	Nil	Died
8	25.10.16. *Str. longus* 4.11.16. *Str. longus*	R.B.C. 3,300,000 Hb. 60 per cent W.B.C. 7,000	Polymorphonuclears 76·4 Lymphocytes, large 8·2 „ small 15·0	Staphylococci	Extra-articular embolus in choroidal vessels	Died
9	1.10.16. *Str. longus*	—	—	—	Nil	Cured
10	10.5.17. *Str. brevis* 14.5.17. Sterile 17.5.17. *Str. brevis*	—	—	Chiefly streptococci	Nil	Still under observation
11	7.5.17. Streptococcus 13.5.17. Sterile	—	—	*B. perfringens* Streptococci	Nil	Cured

3. B. ŒDEMATIS MALIGNI TYPE.

12	15.11.16. *B. œdematis maligni*, with hæmolysis and slight gas	—	—	Streptococci *B. perfringens* *B. œdematis maligni*	—	Died

4. PNEUMOBACILLUS TYPE.

13	8.12.16. Pneumobacillus	W.B.C. 18,400	—	—	Septic bronchopneumonia, both lungs	Died from hæmorrhage

On general treatment one cannot be dogmatic, as many of the cases have got well without any. In others, again, several methods have been exhibited, thus making it difficult to ascribe to any one remedy a specific action. For that type of *B. perfringens* septicæmia described above, general treatment is, apparently, unnecessary, the opsonic power of the blood being quite adequate to cope with the infection.

In other cases, four different methods have been employed: (1) Intravenous saline; (2) Intravenous eusol; (3) Blood transfusion; (4) Autogenous vaccines.

If asked to dogmatize, which one is very unwilling to do, intravenous eusol should be given the place of honour. One says so without definite proof, but, at the same time, fully appreciative of its remarkable stimulating powers and of the improvement which, on occasions, has seemed to follow its use. About one dozen of such infusions have been given, the dose in each instance being 100 c.c. of a 0·5 per cent solution. In no case have any untoward symptoms, except perhaps a rigor, arisen. Its stimulating power exceeds that of saline, for which reason its employment in other cases than blood infections may prove of value. In two cases of streptococcæmia (*Cases* 7, 8) its use was discouraging. It would be unfair, perhaps, to ignore its value in *Case* 6, although one must not lose sight of the fact that in this instance saline infusion and blood transfusion were also employed. One is further inclined to believe that a similar result would not have been secured without its use; or at any rate one can quite plausibly ascribe to its stimulating power the salutary effect it had, at a time when the patient's life was despaired of. The case in question resembled clinically *Case* 5, in which vaccines failed to convince one of their value. Of blood transfusion one can say little, owing to lack of experience. Its employment should not be undertaken lightly, as exceedingly alarming symptoms may arise.

CONCLUSIONS.

The conclusions at which one has arrived from a study of these few cases of septicæmia are: that blood infection occurs more frequently in patients suffering with gunshot wounds than is usually supposed; that this infection may be due to a diversity of organisms; that the clinical manifestations of such a complication may be few and trivial; and that the tendency to natural cure is strong.

The following types of cases would appear, from our experience, to be those worth investigating:—

1. Cases presenting wounds grossly infected with the bacillus of gas gangrene, and exhibiting the symptom-complex associated with the third type of septicæmia described above produced by this organism.

2. Cases exhibiting anæmia and emaciation with wounds of the 'cadaveric' type.

3. All cases in which delirium is present, apart from those in which the position of the wound is such that the condition is intelligible.

4. Cases with temperature disturbance not accountable for by the state of the wound.

PARTICULARS OF CASES.

1. B. PERFRINGENS TYPE.

Case 1.—Pte. D., age 18. Wounded Nov. 13, 1916. Missile, high-explosive shell. Admitted Nov. 15. Diagnosis on admission, gunshot wound of right thigh.

Operation before Admission.—The notes state that there was a penetrating wound of right knee-joint, with compound fracture of patella and external condyle of femur. No foreign body was found. Wound excised, capsule sewn up, and a salt pack inserted.

On Admission.—Temperature 100°, pulse 100, dirty-yellow discoloration of skin. Tongue dry and dirty. Felt and looked remarkably well.

On outer side of right knee-joint was a curved incision parallel to and one inch from the outer border of the patella. Narrow track in centre of incision leads down

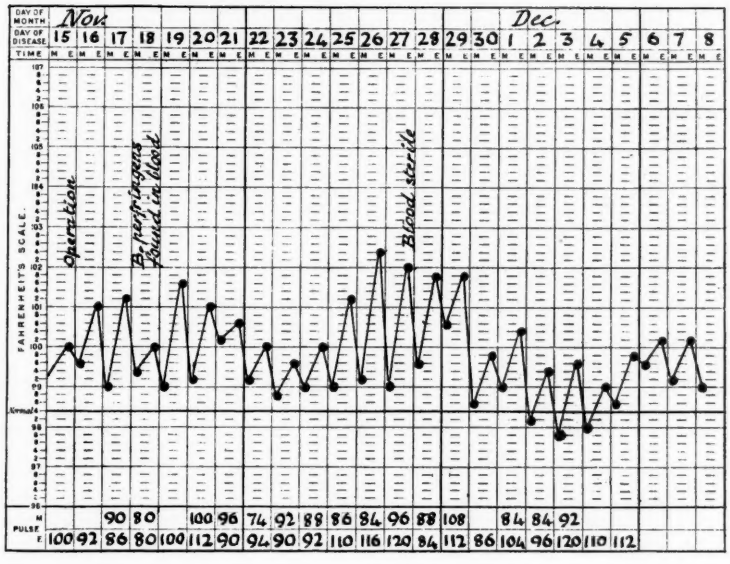


FIG. 325.—*Case* 1. Temperature Chart.

to the external condyle of the femur. No swelling, and very little discharge. The upper anterior surface of the thigh was discoloured, bluish grey, crepitant, and very tender. It was interesting to know that the spread of gangrene in the cellular tissues had been completely arrested distally by the bandage which had been applied firmly round the knee. Proximally the discoloration extended beyond Poupart's ligament.

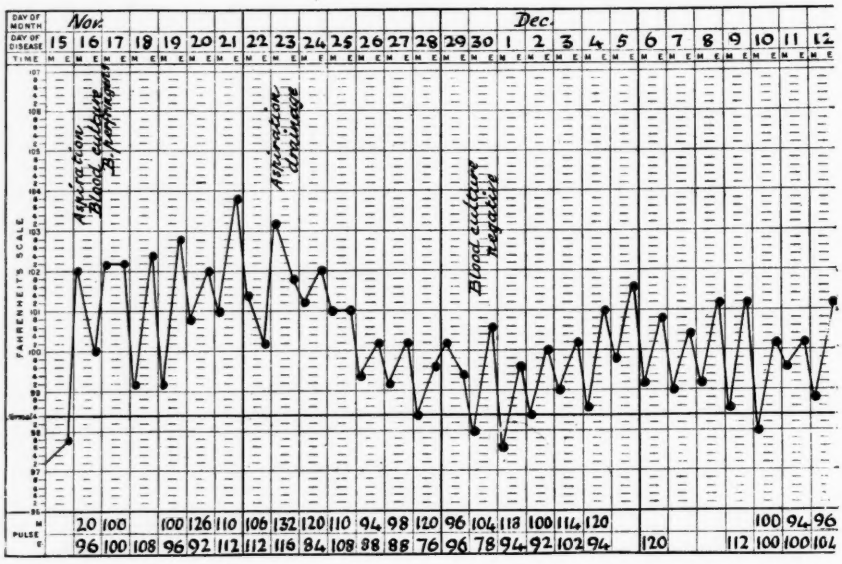
Treatment and Progress.—Multiple incisions in thigh. Foreign body removed, lying deep in muscles of upper part of anterior surface of thigh. Large intramuscular abscess evacuated. Blood culture—*B. perfringens*, with hæmolysis.

Nov. 26: Steady and uneventful recovery. Nov. 27: Blood count—reds 3,480,000, whites 16,800, hæmoglobin 75 per cent; polymorphs 78·8 per cent, large lymphocytes 13·7 per cent, small lymphocytes 7·4 per cent. Blood culture—sterile.

Case 2.—Pte. B., age 32. Wounded Nov. 13, 1916. Missile, high-explosive shell. Admitted Nov. 15. Diagnosis on admission, gunshot wound of both thighs, compound fracture of left femur.

Operation before Admission.—Entry and exit wounds opened freely and drained.

On Admission.—Temperature 97·8°, pulse 120. Patient looks ill. Tongue dry and dirty. Skin shows a dirty-yellow discoloration, with slight icteric tinge of the conjunctivæ. Mentally very dull and apathetic.



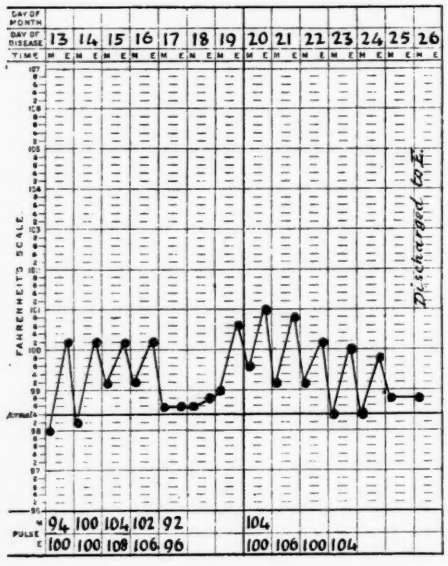


FIG. 326.—*Case* 2. Temperature Chart.

Antero posterior perforating wound of left thigh, with compound comminuted fracture of femur. Exit wound very foul, discharge copious, and limb very swollen.

Treatment and Progress.—Salt packs removed, sloughs cut away, wounds drained, and limb put up in extension. Blood culture—*B. perfringens*, with hæmolysis and abundant gas formation.

Nov. 23: General state much improved. Abscess on anterior surface of lower fragment incised and drained. Nov. 28: Steady general improvement, copious discharge of yellow pus from wounds. Blood count—reds 3,160,000, whites 15,600, hæmoglobin 60 per cent; polymorphs 71·6 per cent, large lymphocytes 9·4 per cent, small lymphocytes 18·8 per cent. Blood culture—sterile. Dec. 24: Discharged to England.

Case 3.—Cpl. P., age 28. Wounded Oct. 20, 1916. Missile, shrapnel. Admitted Oct. 23. Diagnosis on admission, gunshot wound of left leg, fracture of tibia and fibula. No operation prior to admission.

On Admission.—Temperature 102°. Patient extremely ill, anæmic. Dirty-yellow discoloration of skin, and slight icteric tinge of conjunctivæ. Tongue dry and dirty. Complains of severe pain in left leg.

Perforating wound of the upper third of left leg, with compound comminuted fracture of both bones. Exit wound large, fungating, and lacerated, exceedingly foul, and covered with dark brown, stringy, œdematous sloughs. Dark brown discoloration of skin, extending upwards into popliteal space, crepitant on palpation. Copious discharge, containing gas, oozing from wound.

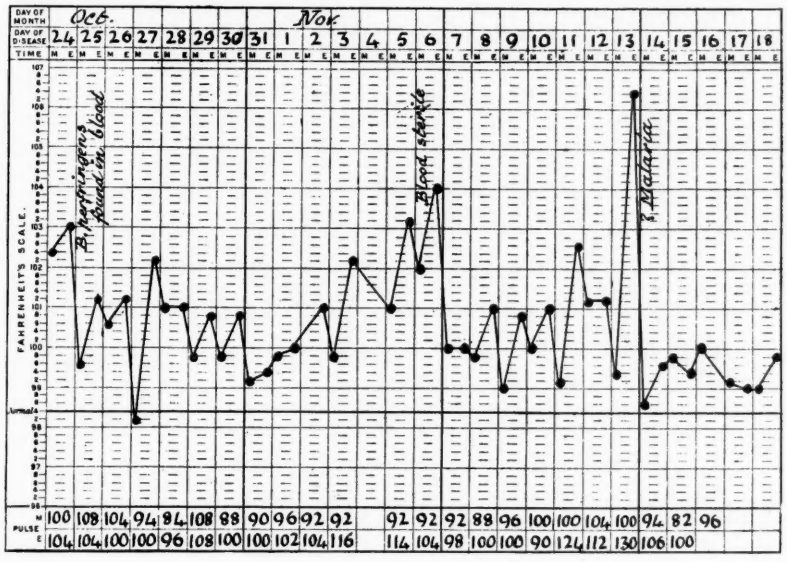


FIG. 327.—*Case* 3. Temperature Chart.

Treatment and Progress.—Oct. 24: Foot dry and cyanosed, cold, pulseless, and insensible. Amputation by transfixion method through lower third of thigh. Blood examination — reds 2,280,000, whites 15,600; polymorphs 73·5 per cent, large lymphocytes 12 per cent, small lymphocytes 14 per cent, eosinophils 0·5 per cent. Blood culture—streptococci and a few *B. perfringentes*.

Oct. 26: Great improvement in general condition. Oct. 30: Improvement maintained. Stump very sloughy. Nov. 2: Improvement continued, stump clean and granulating. Flap approximation commenced. Nov. 5: Stump completely closed. Rolled rubber drain. Nov. 6: Blood culture—sterile. Nov. 10: Rigor, temperature 103·6°, possibly malarial. Nov. 12: Rigor, temperature 104·4°. Stump painless, no swelling, no discharge. Nov. 18: Discharged to England. Stump completely healed.

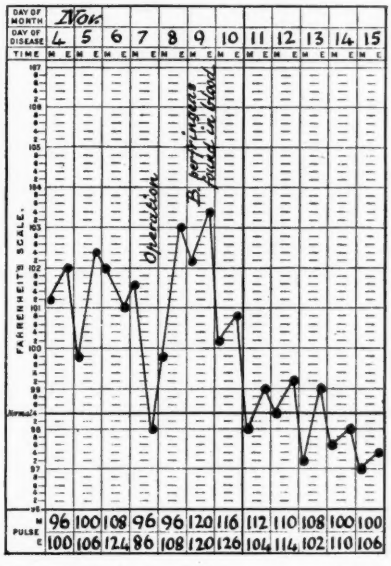


FIG. 328.—*Case* 4. Temperature Chart.

Case 4.—Pte. W., age 22. Admitted Nov. 3, 1916. Diagnosis on admission, perforating rifle grenade wound of left foot.

On Admission.—Patient was pale, and looked very ill. Tongue dry and coated.

Entry wound: Circular in shape, 2 inches diameter, situated on the inner border of distal half of left foot. Exit wound: Large and irregular on the sole and outer side

of middle third of foot, 3 inches in its long axis. The track, which was foul, œdematous, and lined with dark brown, stringy sloughs, passed through the metatarsal region, causing extensive comminution of the first four metatarsals. The discharge was thin, watery, chocolate coloured, copious, and very foul. Bacterio-

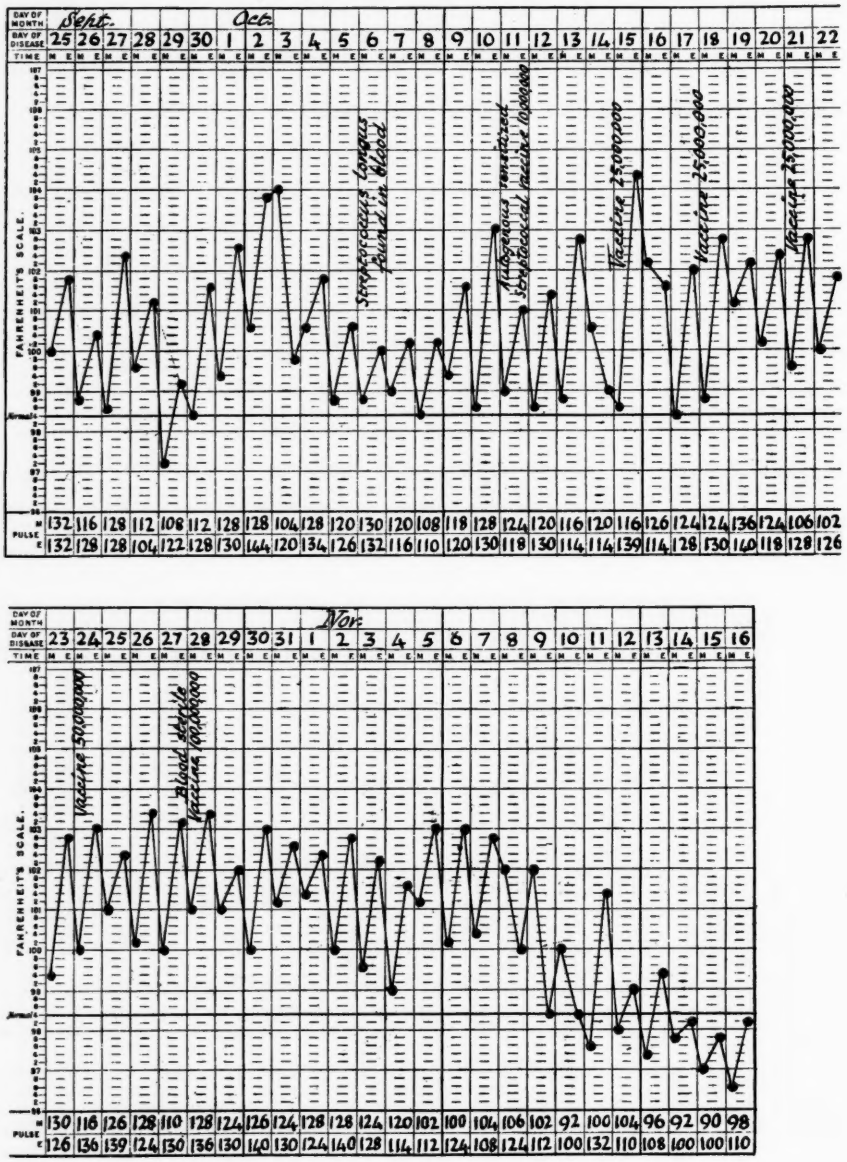


FIG. 329.—*Case* 5. Temperature Chart.

logically, it contained *B. perfringens*, *B. œdematis maligni*, *B. Hibler IX*, free spores, streptococci, staphylococci, and *B. pyocyaneus*. Blood culture—yielded *M. tetragenus* and *B. perfringens*, with gas formation and gelatinization of medium, and subsequent hæmolysis. Blood count—reds 3,200,000, whites 11,000, hæmo-

globin 55 per cent ; polymorphs 79 per cent, large lymphocytes 10 per cent, small lymphocytes 10 per cent, eosinophils 1 per cent.

Treatment and Progress.—Bath for six hours ; eusol fomentations.

Nov. 7 : Temperature ranging between 101° and 103°. Foot became more swollen, with œdema of calf of leg. No crepitation. General condition very poor. Leg was amputated in upper third. For the next two days the temperature remained at 103°, and then came down to normal by crisis. One flap of the stump went gangrenous and was cut away. Nov. 15 : Progress up to this point had been good and rapid ; temperature remained down, and general condition improved markedly ; the stump cleaned up rapidly. Patient here developed tetanus, and died from this complication six days later.

2. STREPTOCOCCUS TYPE.

Case 5.—Pte. M., age 20. Wounded July 1, 1916. Missile, shrapnel. Admitted Sept. 11. Diagnosis, gunshot wound of knee ; amputation.

Operation before Admission, July 5.—Amputation at junction of upper and middle thirds of thigh for gas gangrene.

On Admission.—Temperature 101·6°. Patient very ill, pale, and emaciated. Amputation stump conical, with 2 inches of bone protruding ; exposed surface covered with pale anæmic granulations ; practically no discharge.

Treatment and Progress.—Sept. 16 : Temperature 103° at night. Complains of pain in left groin ; no swelling, but slight tenderness. Movements of hip-joint exceedingly painful. Dry arthritis of hip-joint diagnosed, and limb put up in extension. Sept. 25 : Blood culture—sterile. Sept. 27 : Very troublesome diarrhœa. Oct. 6 : Patient becoming thinner, eats and sleeps badly, slightly jaundiced. Blood culture—*Streptococcus longus*. Oct. 10 : Sensitized autogenous vaccine made, and injections commenced with 10,000,000. Starting pains in left hip-joint at nights. Oct. 14 : 25,000,000 vaccine, followed by marked reaction. Oct. 17 : 25,000,000 vaccine, marked reaction. Pain, tenderness, and swelling around right elbow-joint. Patient very ill. Oct. 20 : 25,000,000 vaccine. Swelling and redness of arm gone. No swelling or pain in left hip-joint. Oct. 23 : 50,000,000 vaccine. Oct. 26 : 100,000,000 vaccine. Oct. 27 : Blood culture—negative. Oct. 29 : Temperature 104°. Slight œdema in left groin. Nov. 11 : Three ounces of pus evacuated by incision above and parallel to Poupart's ligament. Nov. 22 : Incision in right groin healed. General condition much better. Dec. 19 : Discharged to England.

Case 6.—Pte. C., age 22. Wounded Jan. 6, 1917. Missile, shrapnel. Admitted Jan. 10. Diagnosis, gunshot wound of thigh and leg.

Operation before Admission, Jan. 6.—Wounds excised and drained.

On Admission.—Temperature 100·6°, pulse 100. Patient very anæmic, and looked ill. Slight icteric tinge of conjunctivæ. Tongue dry and dirty. Pulse small and poor.

Two penetrating wounds on inner aspect of lower half of left thigh. Track in each case leads directly outwards for 3 inches. Copious discharge of yellow pus. There was an elliptical excised wound 5 inches long, extending deeply behind the tibia. Wound surfaces were covered with stringy, œdematous, dark-brown sloughs. There was considerable necrosis of the intermuscular septa, and a copious foul discharge. There were numerous small penetrating wounds on back, and right thigh.

Treatment and Progress.—Jan. 12 : Operation. Wounds cleaned up, all slough cut away, and Carrel's treatment instituted. Jan. 13 : Wounds extremely foul, and of 'cadaveric' type. Eusol fomentations applied. Jan. 14 : Intravenous eusol, 100 c.c. Jan. 16 : All slough separated from wound ; exposed tissues pale, painless, soft, desiccated, and elastic ; practically no discharge. Blood culture—yielded *Streptococcus longus*, growing more profusely in anaerobic culture, and with distinct hæmolysis Intravenous eusol, 100 c.c., with saline 10 ounces. Jan. 17 : Patient *in extremis*. Exceedingly pale and thin, pulse running and almost uncountable, respirations very shallow, skin cold and dry, slight delirium at times, practically

no discharge from wound. Secondary hæmorrhage from posterior tibial artery; amputation through lower third of thigh. Intravenous eusol, 100 c.c., saline 10 ounces. Jan. 18: Patient still very ill. Citrated whole blood, 16 ounces, injected intravenously. Feb. 10: There has been a gradual and slight improvement in

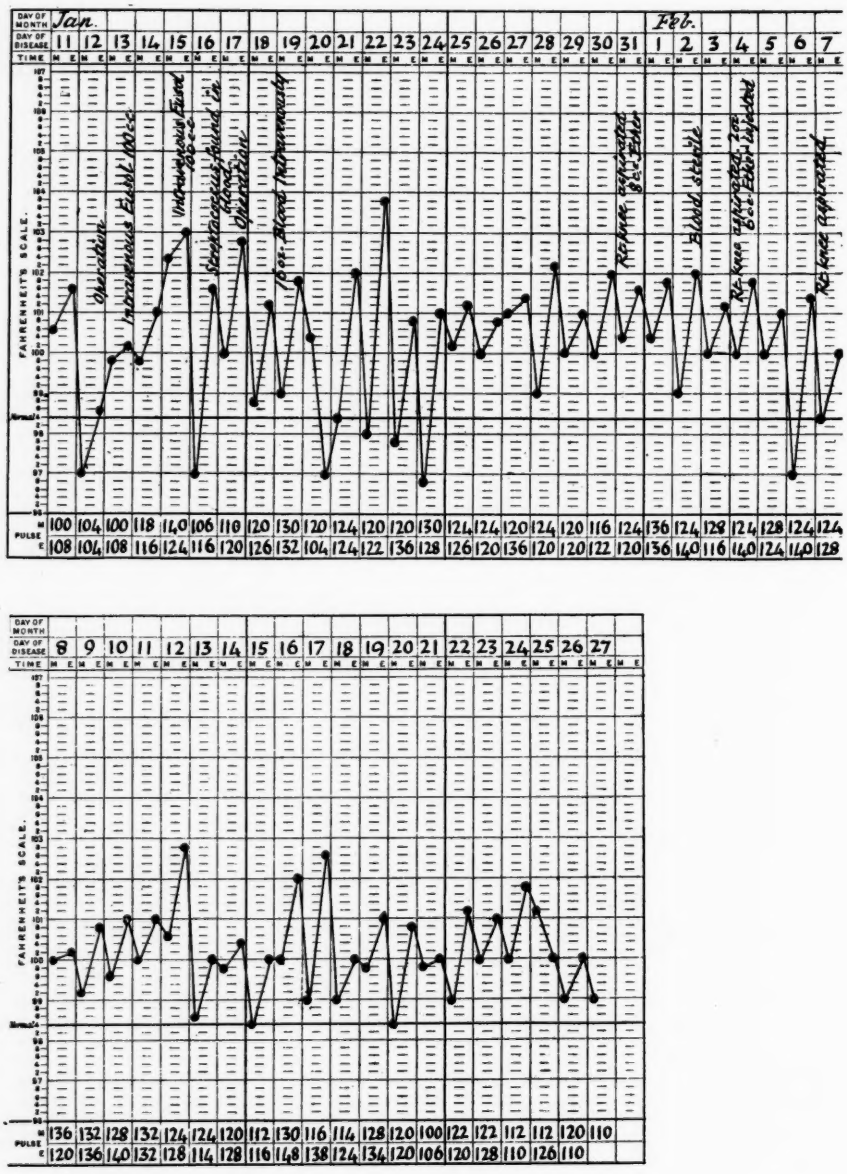


FIG. 330.—*Case* 6. Temperature Chart,

patient's general condition, the wounds remaining in the 'cadaveric' state. Several abscesses developed in connection with wounds of both thighs, and these were opened and drained. Feb. 14: Wounds healthy and granulating. The general condition much improved. Feb. 27: Discharged to England cured.

Case 7.—Pte. C., age 25. Wounded Oct. 20, 1916. Admitted Oct. 24. Diagnosis, gunshot wound of buttock.

Operation before Admission.—Wound excised and drained.

On Admission.—Temperature 102°, pulse 96. Patient mildly delirious, and complaining of pain in right leg and right hypogastrium.

Large excised wound of the right buttock, extending deeply into muscles, moderately clean, and a moderate amount of discharge. Swelling, œdema, and tenderness of middle of posterior aspect of right thigh.

Treatment and Progress.—Slight improvement in general condition; but still delirious. Abscess in thigh extending from buttock wound opened and drained. Syringed and dressed with eusol three times daily.

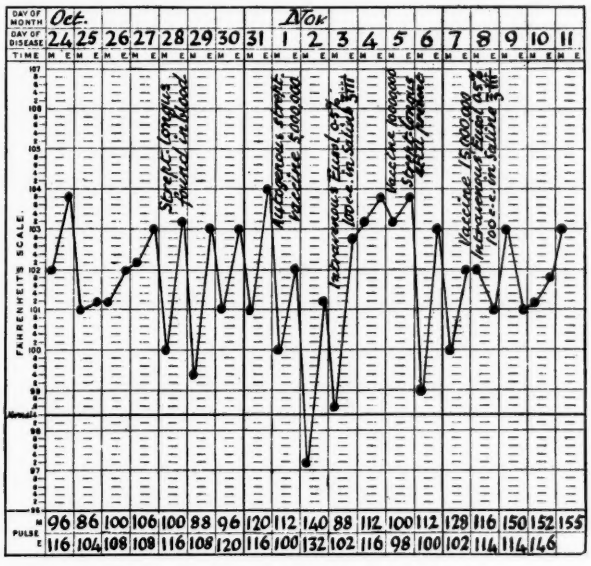

DAY OF MONTH
Oct.
Nov.
DAY OF DISEASE
24 25 26 27 28 29 30 31 1 2 3 4 5 6 7 8 9 10 11
TIME
FAHRENHEIT'S SCALE
Streptococcus longus found in blood
Autogenous streptococcal vaccine 5,000,000
Intravenous eusol 100 c.c. in saline 5%
Vaccine 10,000,000 Streptococcus longus found
Vaccine 15,000,000 Intravenous eusol 100 c.c. in saline 5%
PULSE
M 96 86 100 106 100 88 96 120 112 140 88 112 100 112 128 116 150 152 155
E 116 104 108 108 116 108 120 116 100 132 102 116 98 100 102 114 114 146

FIG. 331.—*Case* 7. Temperature Chart.

Oct. 28: Blood culture—yielded *Streptococcus longus* in pure culture. Nov. 1: Autogenous streptococcal vaccine, 5,000,000. Wound drained satisfactorily. General state, *in statu quo*. Nov. 3: Intravenous eusol, 100 c.c. Nov. 5: Vaccine, 10,000,000. Blood culture—*Streptococcus longus*. Nov. 7: Vaccine, 15,000,000. Nov. 8: Intravenous eusol 0·5 per cent, 100 c.c. Nov. 11: Patient died.

During the whole course of the disease patient was delirious; he slept and ate moderately well. The progress of the wound was satisfactory. The terminal stages of the disease were complicated by increase in delirium, emaciation, profuse sweating, and incontinence of urine and fæces. No metastases were observed, and a post-mortem was not performed.

Case 8.—Pte. B., age 25. Wounded Oct 5, 1916. Missile, shrapnel. Admitted Oct. 8. Diagnosis, gunshot wound of thigh.

Operation before Admission.—Excision of wounds.

On Admission.—General state fair, tongue clean. Temperature 100°, pulse 70.

Large circular excised wound 2½ inches in diameter, base fairly clean, marked reaction in surrounding skin.

Treatment and Progress.—Steady general improvement for five days after admission.

Oct. 19: Temperature 105°, pulse 88. Does not complain of pain. Wounds satisfactory. Abdomen and chest, nothing abnormal. Oct. 22: Temperature 104·8°, pulse 80. Delirium of a hysterical nature. Oct. 23: Urine examined,

*

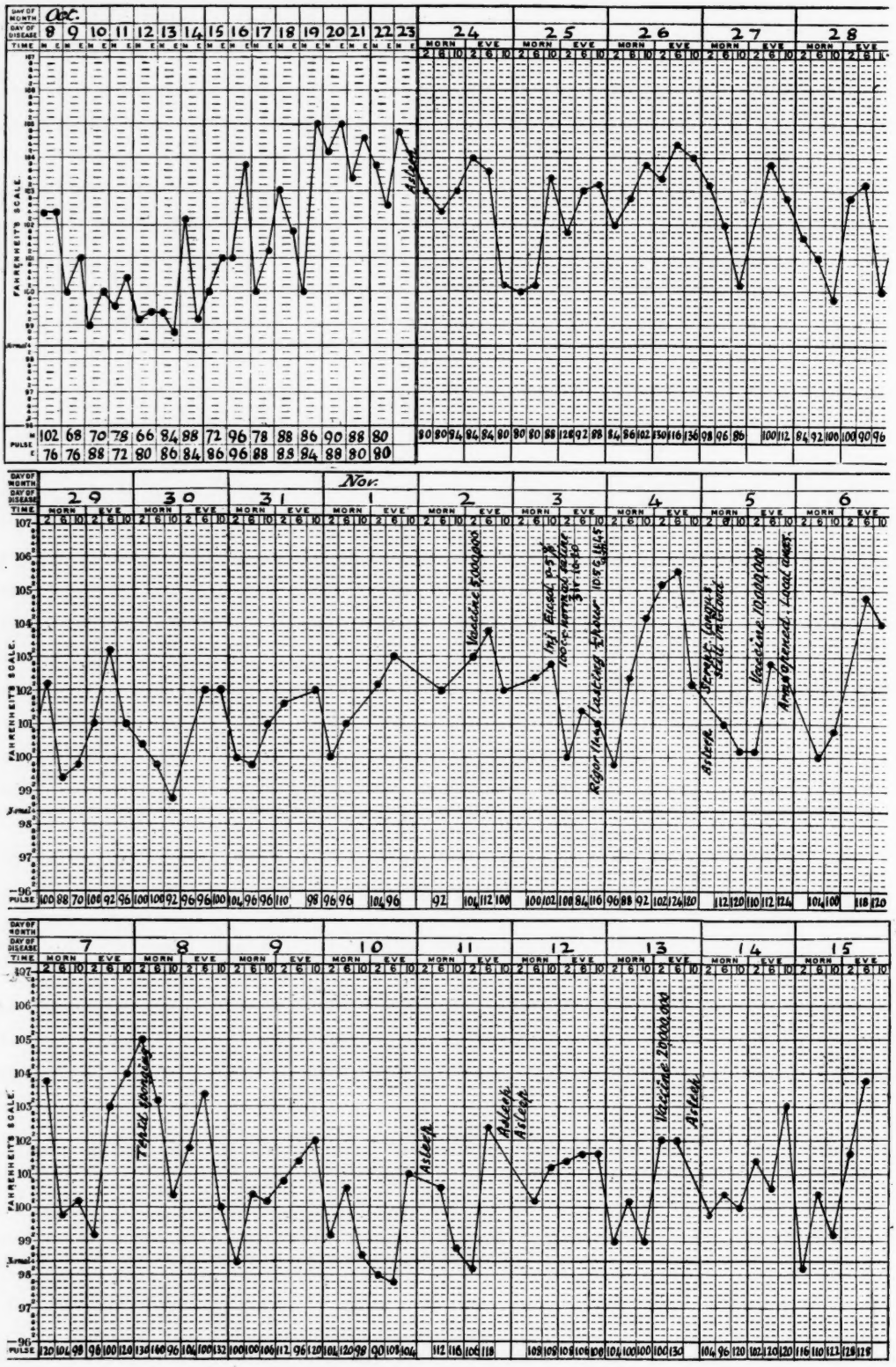


FIG. 332.—*Case* 8. Temperature Chart.

nothing abnormal found. Leucocytosis 7,000. Widal negative. Fæces examined, *B. coli* only found. Heart, lungs, and abdomen normal. Wounds healing rapidly. Oct. 25: *Streptococcus longus* in pure culture found in blood. Delirious during the greater part of the day. Oct. 26: Diarrhœa. Eusol, 100 c.c., intravenously. Oct. 27: Swelling, œdema, and redness round both elbow-joints and left wrist-joint. Oct. 29: Patient getting worse. Nov. 1: Embolus in left choroidal vessels. Nov. 4: Right arm opened and 4 ounces of pus evacuated; no bone or joint involvement. Autogenous antistreptococcal vaccine, 10,000,000, given. Nov. 14: Patient much weaker. Incontinence of urine and fæces. Very free perspiration. Wounds healing. Nov. 15: Patient died comatose.

Case 9.—Pte. W., age 27. Wounded Aug. 29, 1916. Missile, bomb. Admitted Sept. 3. Diagnosis, gunshot wounds, multiple.

Operation before Admission.—Excision of wounds, and drainage. Left shoulder-joint excised.

On Admission.—General condition good.

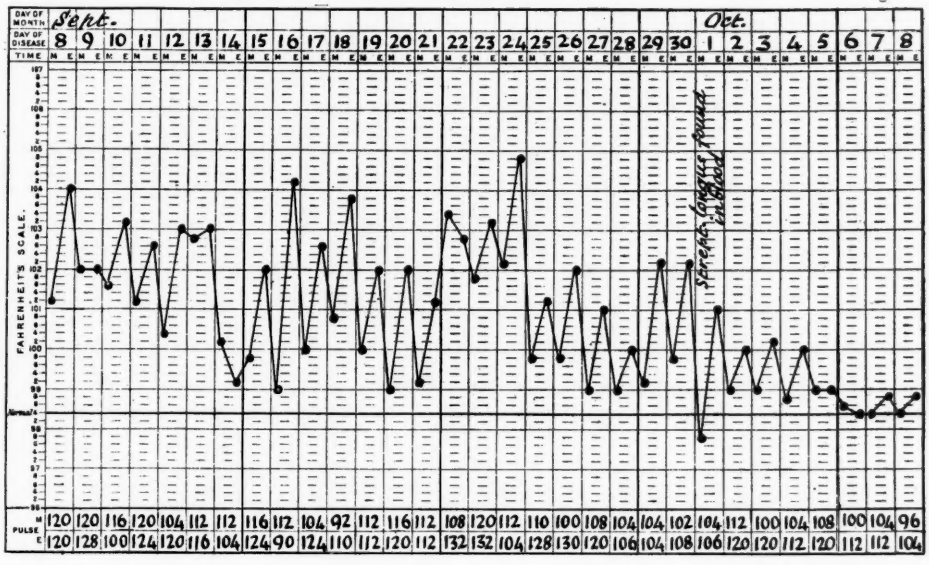


FIG. 333.—*Case* 9. Temperature Chart.

Penetrating wounds of both shoulders, both elbows, both wrists, and left ankle-joint. Wounds were all in a satisfactory condition, and draining well.

Treatment and Progress.—Dressed with eusol three times daily. Apart from temperature, patient's progress was very satisfactory.

Oct. 1: Blood culture—*Streptococcus longus.* Oct. 5: Temperature normal. Oct. 19: Discharged to England.

Case 10.—L.-Cpl. R., age 22. Wounded April 23, 1917. Missile, whizz-bang. Admitted May 3. Patient lay out two days after being wounded.

Operation before Admission.—Wounds had been excised.

On Admission.—Slight degree of anæmia, and a tired expression. Says he feels well. Temperature 98°.

There were two penetrating wounds on the outer side of the right thigh, each about the size of a florin. The track in each invades the superficial layers of underlying muscle only. Discharge moderate in amount, yellow in colour, and thick in consistence. It contains streptococci chiefly. Granulations are abundant, but pale and œdematous.

Treatment and Progress.—May 7: Temperature 103°. Mild delirium and drowsiness. Wounds are still in a callous state. No pain, tenderness, or swelling. Says he feels very well. May 8: Streptococcus isolated from blood. General

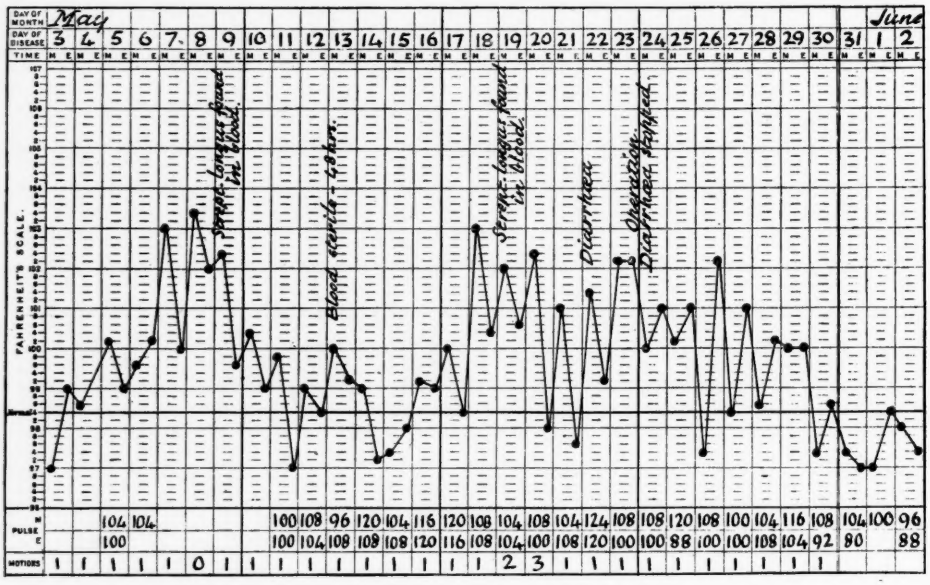


FIG. 334.—*Case* 10. Temperature Chart.

condition of patient quite satisfactory. No special treatment adopted. Wounds *in statu quo*. May 14: Blood sterile. Delirium and drowsiness quite gone. Patient looks well, is not so anæmic, looks and feels well. One wound in thigh almost healed. The other is discharging slightly. May 18: Temperature 103°. More discharge from wound. Patient very drowsy, and not looking quite so well. May 19: Streptococcus found in blood. May 21: Slight attack of diarrhœa. May 24: Wounds explored—very satisfactory. General condition of patient is remarkably good. He eats and sleeps well. His drowsiness has quite gone.

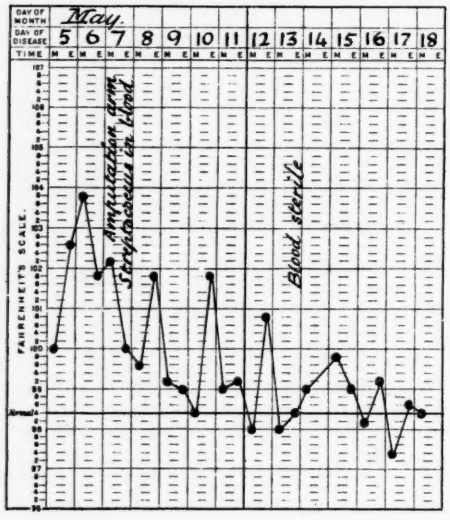


FIG. 335.—*Case* 11. Temperature Chart.

Case 11.—Pte. W., age 25. Wounded May 3, 1917. Missile, machine-gun bullet. Admitted May 4.

On Admission.—Severe perforating wound of right forearm just below elbow-joint, with comminuted fracture of ulna. Discharge copious, and containing bubbles of gas. Arm swollen and œdematous. No radial pulse. Pus from wound contained *B. perfringens* and streptococci.

Treatment and Progress.—May 5: Wound opened up and drained. Hole found in wall of radial artery, which was blocked by septic clot. One and a half inches of artery resected. May 7: Rapidly

spreading emphysematous gangrene of forearm. Amputation through middle of upper arm. Blood culture—streptococcus isolated. Further progress uneventful. Blood sterile on sixth day after amputation.

The blood for investigation was taken immediately before amputation. The general condition of the patient, on admission, very closely resembled that associated with the mild type of septicæmia produced by the bacillus of gas gangrene.

3. MALIGNANT ŒDEMA TYPE.

Case 12.—Pte. J., age 33. Wounded Nov. 13, 1916. Missile, shrapnel. Admitted Nov. 15. Diagnosis on admission, gunshot wound of legs. No operation on admission.

On Admission.—Temperature 102°. Exceedingly ill, pulse almost uncountable; very pale, and slightly jaundiced. Mentally, remarkably clear. Has no pain, feels quite comfortable and contented.

Lacerated elongated wound 6 inches long on outer surface of left thigh just above great trochanter. Several penetrating wounds on posterior aspect of both calves. Wounds extremely foul, covered with black, closely-adherent sloughs, bleeding on removal. An almost continuous flow of thin, dark-brown fluid. Left lower extremity as far as knee was cold, black, and tympanitic. Right foot and lower third of leg black and gangrenous. Skin beyond this as far as knee raised in blebs containing dark-brown putrid fluid.

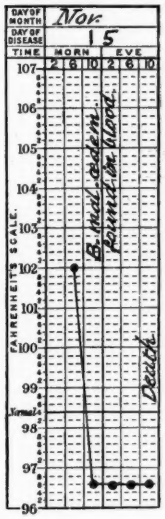


FIG. 336.—*Case* 12. Temperature Chart.

Treatment and Progress.—Stimulants. Eusol, 100 c.c., intravenously. Eight hours later the gangrene has spread as far as the middle of both thighs. The thermometer failed to register, and the pulse was uncountable. During this time the dressings and mattresses were several times soaked with discharge. Death ensued twenty-one hours after admission. Patient was perfectly conscious until within five minutes of death. Pus contained *B. perfringens* and *B. œdematis maligni*. Blood culture—*B. œdematis maligni*, with marked hæmolysis.

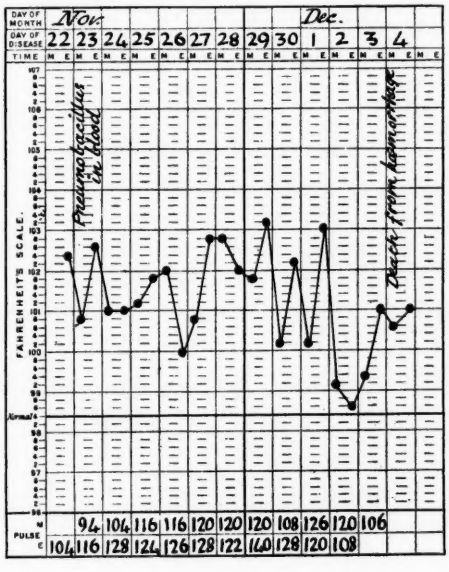

DAY OF MONTH
Nov
Dec.
DAY OF DISEASE
22 23 24 25 26 27 28 29 30 1 2 3 4
TIME
M E M E M E M E M E M E M E M E M E M E M E M E M E
FAHRENHEIT'S SCALE.
Normal
Pneumococcus in blood
Death from hæmorrhage
PULSE
M 94 104 116 116 120 120 120 108 126 120 106
E 104 116 128 124 126 128 122 140 128 120 108

FIG. 337.—*Case* 13. Temperature Chart.

4. PNEUMOBACILLUS TYPE.

Case 13.—Pte. H., age 26. Wounded Nov. 14, 1916. Admitted Nov. 2?. Diagnosis, gunshot wound of right groin. Missile, high-explosive shell.

On Admission.—Patient very pale and haggard, slightly cyanosed, but not complaining much of pain; tongue dry and dirty. Temperature 102°, pulse 104.

Entry wound: Circular, 1 inch in diameter, above and external to middle of right buttock. Exit wound: Large and irregular, about 4 inches long, situated in right groin. Extremely foul, and discharging copious foul pus.

There was a patchy consolidation of the right base.

Treatment and Progress.—Nov. 24: Eusol dressing to wound, and stimulants. Secondary hæmorrhage from obturator artery. Artery tied. Large area of gangrene palpated in pelvis through obturator foramen. Area cleaned up and drained.

Counter-incision for drainage immediately above outer half of Poupart's ligament. Intravenous saline, 1 pint, normal horse serum, 10 c.c. hypodermically; calcium lactate, gr. x, three times daily.

Nov. 25: Blood examination—coagulation time, eight minutes; leucocytes 18,400. Blood culture—yielded pneumobacillus. Nov. 26: Examination of sputum—pus cells numerous; gram positive bacilli and streptobacilli predominating organism. Intravenous saline, 1 pint. Nov. 27: Patient very weak and ill; had several syncopal attacks. Nov. 29: Slight general improvement. Right ankle swollen, œdematous, and tender. Wound cleaned. Dec. 2: Great improvement in general state. Dec. 4: Improvement maintained, wounds granulating nicely, practically no discharge. Dec. 5: Secondary hæmorrhage and death.

Post-mortem.—Wounds of entry and exit, and track of missile, were fairly clean; there was some sloughing of the track in the neighbourhood of the pelvis, and the muscles were friable and œdematous. Hæmorrhage was found to have occurred from a branch of the obturator artery. There was a slight fracture of the pubic arch on the upper surface, but no gross lesion anywhere. Both lungs showed a septic bronchopneumonia.

TWO CASES OF SQUAMOUS EPITHELIAL TUMOUR OF THE BREAST.

By RAYMOND JOHNSON, London,
and T. W. P. LAWRENCE, London.

The rarity of tumours of the breast containing squamous epithelium is sufficient to justify the publication of the two cases with which this short communication deals.

Ordinary squamous-celled carcinoma arising in the cutaneous covering of the breast calls for no particular remark. Examples of squamous-celled carcinoma originating deeply in the breast substance are also on record. Such tumours may be supposed to have their origin either in rests, or in a reversion of the glandular epithelium to the original type in which the epithelium of the breast takes its origin (metaplasia).

In the two cases here recorded, the growth presented itself as a definite tumour of the breast, and in each the outstanding histological feature was the presence of squamous epithelium with well-developed prickle cells.

The first case was that of a married woman, age 53, who accidentally discovered a lump in the left breast three weeks before she came under observation.

On examination, a rounded tumour as large as a walnut was present in the upper and outer quadrant of the breast. The nipple was normal, and the tumour, although intimately connected with the breast tissue, was not attached to the skin or deeper structures. There were no palpable glands in the axilla. The tumour appeared to be slightly elastic, and was thought to be a cyst.

It is interesting to mention that three of the patient's sisters had had cysts of the breast. In one, a cyst had been excised; in another, two cysts had been punctured; and in the third, two operations had been performed for multiple cystic disease.

The tumour, on removal, proved to be a solid growth, and was regarded as a carcinoma. The whole breast, with the pectoral muscles and axillary contents, was therefore removed. A year later there was no evidence of recurrence.

Description of Specimen.—The tumour is ovoidal in shape, and measures 5 cm. in its longest diameter. In the fresh state the consistence was moderately firm, and the surface of the section presented an opaque white colour and coarse granular structure. After hardening in formalin, a fresh section of the tumour shows to the naked eye a grey fibrous-looking ground-substance, in which are irregular opaque areas of a yellowish-white colour. The tumour has a well-defined outline, but is intimately connected with the surrounding breast tissue and fat.

FIG. 338.

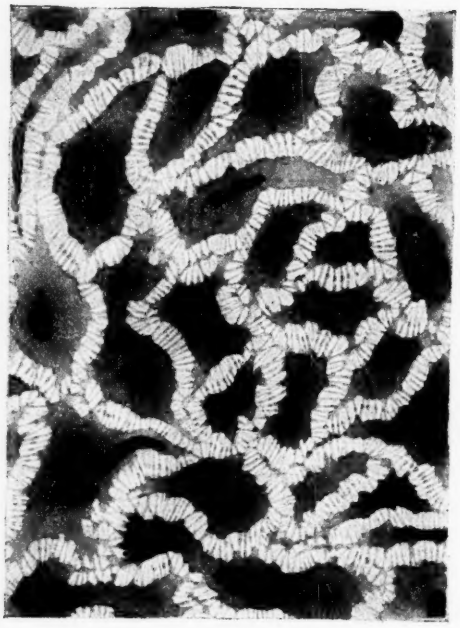


FIG. 339.

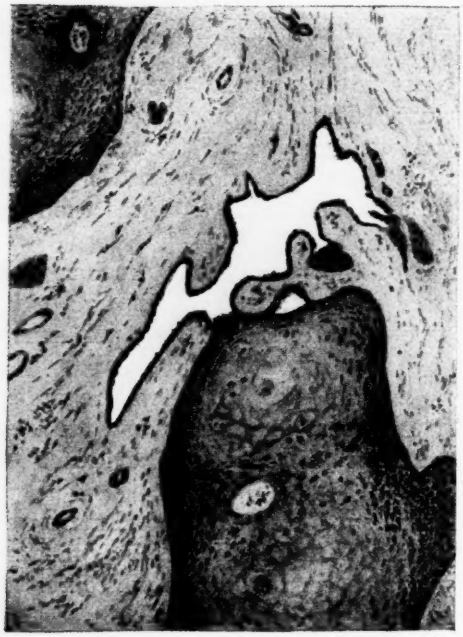


FIG. 340.

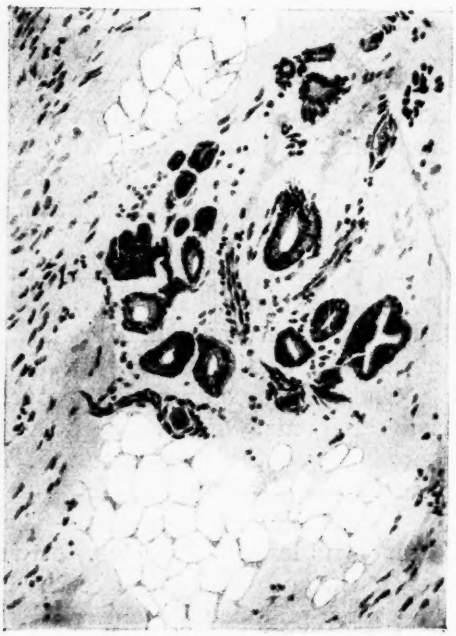


FIG. 341.

SQUAMOUS EPITHELIAL TUMOUR OF THE BREAST.

Drawn by T. W. P. Lawrence, F.R.C.S.

The remainder of the mammary gland is atrophied, but otherwise normal in appearance. The axillary fat contains several glands, the largest of which is 1·5 cm. in length and presents a narrow zone of lymphoid tissue around a fatty centre.

Microscopic Structure.—The outstanding feature in the structure of the tumour is the presence of irregular masses of epithelium (*Fig.* 338), the cells of which are in a large measure very perfectly developed prickle cells (*Fig.* 339). In each epithelial mass, the cells which lie next the stroma are small flattened prickle cells. Beneath these is a thick layer of larger prickle cells. Still nearer the centre of the mass is a thin layer of swollen cells in which prickle cells are almost completely absent. These cells stain blue with hæmatoxylin, and some of them contain masses of fine granules. Lastly, the centre of the mass is composed of nucleated squamous cells, staining pink with eosin, and in many places arranged in cell-nests. There is no evidence of degeneration of the cell masses. No structures resembling papillæ are to be seen. Interspersed among these masses are numerous irregular gland-like spaces, lined with irregular spheroidal epithelium in layers of from one to three cells. Some of the spaces contain a structureless or finely granular substance staining pink with eosin. In some places a direct transition of the epithelial lining of these glandular spaces into the masses of prickle cells can be traced (*Fig.* 340). The stroma for the most part stains blue, and is composed of a loose cellular connective tissue ; in other parts it is pink, and is composed of bundles of white fibrous tissue containing spindle-shaped nuclei. Scattered through the tumour are small islands of breast tissue, with fat (*Fig.* 341). The stroma around these islands shows a lymphocytic exudation, but no such exudation is present elsewhere. The axillary lymphatic glands removed show no deposit of growth.

A search through the literature of the subject shows that the tumour most closely resembling that now under consideration is one described by Konjetzny (*Beitr. z. klin. Chir.*, 1912, lxxviii). This tumour occurred in a woman, age 34, who was pregnant at the time ; it had been noticed for six months, and was situated in the outer part of the right breast. The tumour after removal measured 15 cm. by 8 cm., and consisted of a cyst surrounded by solid growth. Microscopically, the solid part of the tumour showed cell masses consisting of typical stratified squamous epithelium with very perfectly developed prickle cells. Besides these there were small masses of rounded cells, having in parts an alveolar arrangement, and without prickle cells. The axillary glands showed a simple inflammatory hyperplasia. No direct connection of the tumour tissue with that of the breast could be demonstrated, and Konjetzny suggests that the tumour probably had its origin in an early embryonic ectodermal rest.

Small masses of squamous epithelium, sometimes mixed with cholesterin to form cysts, are occasionally met with in tumours having the general characters of fibro-adenoma.

The second case was that of a married woman, age 50, who was admitted into University College Hospital, April 3, 1913, with a tumour of the left breast which had been noticed for four months. An " abscess " formed in the tumour, and, after poulticing, discharged through the skin.

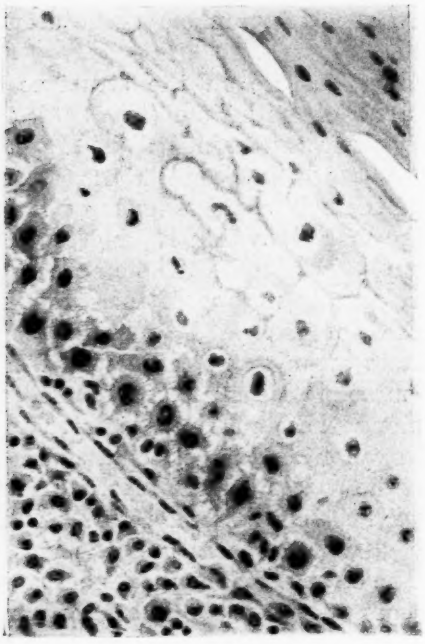


FIG. 342.

FIG. 343.

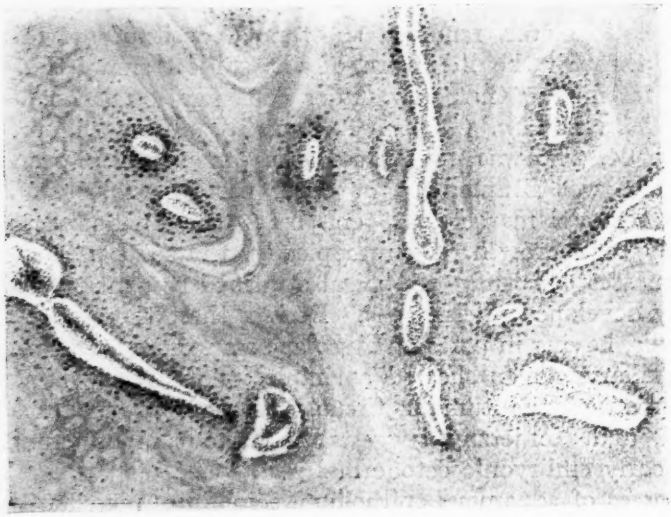


FIG. 344.

SQUAMOUS-CELLED CARCINOMA OF THE BREAST.

Drawn by T. W. P. Lawrence, F.R.C.S.

On admission to the hospital, there was a prominent tumour, 3 in. in diameter, in the upper and inner quadrant of the left breast. The overlying skin was reddened, and the centre had broken down to form a small round ulcer with soft flat base and thin non-indurated margins. From the ulcer a probe could be passed into the centre of the growth for 2½ inches. There was a free discharge of yellow serous fluid. The whole tumour was soft, and the skin, except at the margin of the ulcer, was not infiltrated. The remainder of the breast appeared to be normal, and the tumour was not fixed to the pectoral muscle. Two enlarged hard glands could be felt in the axilla, and another as large as a pea in the poster or triangle of the neck. There were no evidences of secondary deposits in the thorax or abdomen.

The breast, together with the axillary contents and the pectoral muscles, was removed.

Description of Specimen.—A section through the breast, after hardening in formalin, shows that the peripheral part of the tumour, which is intimately connected with the surrounding fat and the remains of the breast tissue, is of a uniform yellowish-white colour, whilst the central part is broken down into an irregular cavity. The tumour extends into the breast for 7 cm. beneath the skin. Superficially the growth extends to the floor of the ulcer above mentioned, and in this situation takes the form of small opaque white strands in the subcutaneous fat. The nipple is separated by 3 cm. from the edge of the growth; it is normal, and beneath it is a small area of breast tissue.

Microscopic Structure.—The tumour is a squamous-celled carcinoma. The epithelium is arranged in masses, in each of which is a central core of loose connective tissue (***Fig.*** **344**). The layer of cells immediately surrounding the connective tissue presents the appearance of those of the Malpighian layer of the skin, whilst peripheral to these are gradations passing to horny scales (***Fig.*** **342**). In places well-marked prickle cells are present (***Fig.*** **342**). The axillary lymphatic gland examined is infiltrated with masses of squamous cells (***Fig.*** **343**).

In the second of these two cases we have no doubt that we are dealing with a squamous-celled carcinoma originating in the skin overlying the breast, and with the naked eye it was possible to trace fine lines of opaque growth between the surface of the tumour and the skin itself. The structure of the tumour is in one respect peculiar, in that the epithelial masses, instead of presenting the usual alveolar structure, have retained an exaggerated papillary arrangement, so that these masses in section are seen to enclose a core of cellular connective tissue (***Fig.*** **344**).

The true nature of the first specimen is less apparent. Among the reasons that lead us to believe that the tumour is not a carcinoma are: (1) The association of gland-like spaces with the epithelial masses; (2) The abrupt change from the small cubical epithelium of the spaces into the squamous epithelium of the cell masses; and (3) The regularity of the cells of the squamous epithelial masses. Possibly the tumour is allied to those recorded by Wilms, Beneke, and others, in which epithelial pearls are present in fibro-adenomas.

REMOVAL OF A RIFLE BULLET FROM THE RIGHT LOBE OF THE CEREBELLUM; ILLUSTRATING THE SPONTANEOUS MOVEMENT OF A BULLET IN THE BRAIN.*

By GEOFFREY JEFFERSON,

Chief Surgeon to the Anglo-Russian Hospital, Petrograd.

The following case is chiefly interesting as being a good example of the spontaneous movement of a bullet within the brain. Indeed the bullet not only moved, but turned round—spontaneous version.

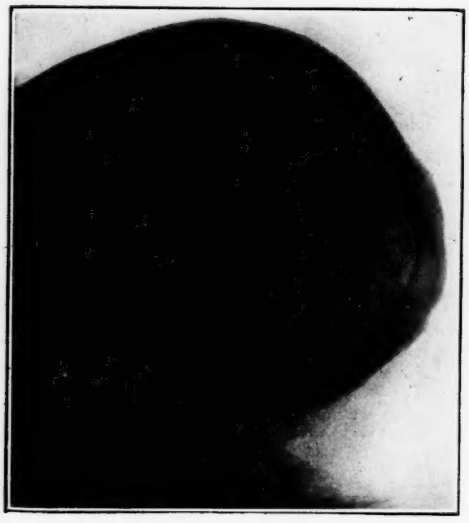


Fig. 345.—Lateral view of skull. Bullet lies nose downwards and forwards in cerebellum, 3 cm. from os occipitale. The x marks point of entry.

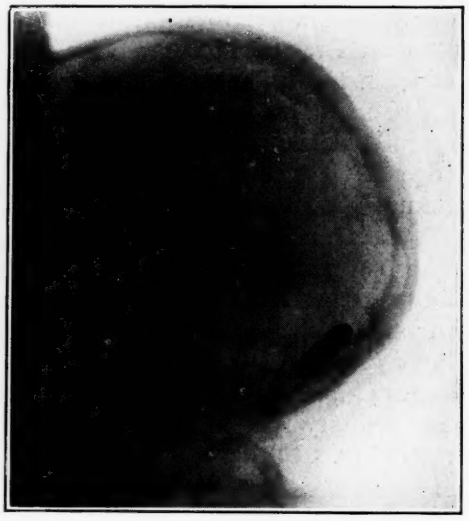


Fig. 346.—Lateral view of skull 19 days later. Bullet now lies nose upwards 1 cm. from os occipitale.

The patient was a Tartar boy, age 18, a chauffeur. He was shot in the head on the afternoon of Feb. 28, 1917, during the Revolution. Judging by the position of the wound and by the course taken by the bullet, the shot was probably fired from a house-top. He was admitted to the Anglo-Russian Hospital in a semi-conscious condition within a few minutes of being wounded. He vomited several times in the first half-hour. The wound was situated 12 cm. above and 1 cm. behind a line drawn vertically upwards from the pre-auricular point. The scalp was shaved and the wound explored, without

* Paper read and case exhibited before the Russian Surgical Society of Pirogov, Petrograd, May 23, 1917.

anæsthesia. The bullet track ran downwards and backwards through the meninges. There was remarkably little splintering of the skull. The bullet was not palpable. The patient was *x*-rayed the following day, and a rifle bullet was seen to be lying in the right cerebellar fossa. The bullet lay obliquely, with its nose downwards, inwards, and forwards, suggesting that it had been deflected somewhat after entering the skull. It lay embedded some 3 cm. deep in the right lobe of the cerebellum (***Figs.* 345, 347**). Considering the serious condition of the patient and the depth of the projectile, it was considered inadvisable to attempt immediate removal. Clinically, the chief localizing signs were nystagmus towards the right, a tendency to fall always towards the right side when made to take a few steps, and right-sided dysdiadochokinesia.

During the ensuing days he gradually improved, and on March 19 fresh *x*-ray photographs (a stereoscopic pair) were taken preliminary to operation.

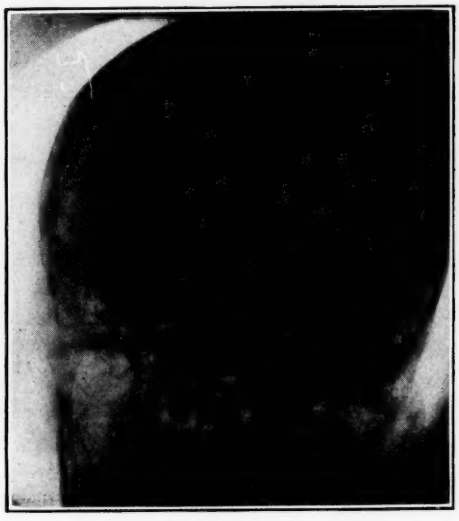


FIG. 347.—Antero-posterior view of skull. Bullet lies obliquely in right lobe of cerebellum, its base towards middle line. (Plate made with tube in front, plate behind.)

FIG. 348.—Antero-posterior view of skull 19 days later. Bullet lies almost horizontally, base outwards. (Plate made with tube behind, plate in front.)

It was now seen that the bullet had moved during the nineteen days that the patient had lain upon his back. It had sunk backwards until it was now separated from the inner surface of the occipital bone by barely 1 cm. This general movement backwards had been accompanied by a version of the bullet, so that its nose, which formerly pointed forwards, downwards, and inwards, now pointed backwards, upwards, and inwards (***Figs.* 346, 348**), the general lie of the bullet being now horizontal. The bullet had therefore traversed a distance of some 2 cm., and, as will be seen from the plates, its base had gone through a relatively large excursion.

It is unfortunate that the later antero-posterior radiograms were taken from before backwards, the earlier one having been taken in the reverse

direction. However, there can be no doubt about the fact that the bullet has actually moved considerably in this case, though Gamlen and Smith[1] are doubtless right in believing that such movement is often apparent only, due to failure to reduplicate exactly the former position of the head.

On March 24 the bullet was easily extracted from the right lobe of the cerebellum. The upper fibres of the trapezius had to be divided at their origin from the os occipitale, and after removing a disc of bone with a hand trephine, bone was clipped away freely. The lateral sinus was exposed in this procedure, and the dura incised horizontally below it. The bullet was found lying in a shallow abscess cavity, the pus from which proved to be sterile on culture. The patient made an uneventful recovery. Six weeks after operation the only symptom remaining was the dysdiadochokinesia.

At no time was there any disturbance of vision, yet the line of the bullet, had it taken a direct course, must have passed through the right calcarine fissure. My confrère, Professor Poussep, suggested that in view of this absence of visual upset, it is probable that the bullet ran backwards, pierced the left tentorium cerebelli, and then crossed into the right cerebellar lobe. This, I think, is very probably the correct interpretation. A slowly-travelling bullet would easily be deflected by so rigid a structure as the tentorium.

As to the wandering of the bullet, Flourens, it is interesting to recall, found that bullets experimentally introduced into the cerebrum and cerebellum always tended to sink towards the base of the skull.[2] Krause, in his monograph,[3] records a case where a revolver bullet moved a considerable distance (Kugelwanderung) in a few weeks and then came to rest. Vilvandré and Morgan[4] have published a case in which a shrapnel ball apparently rolled round as well as sank backwards.

In general, the movement of bullets in the substance of the brain must, I think, be attributed to a combination of any or all of the following factors :—

(1) The action of gravity, the specific gravity of the bullet being far higher than that of the brain ; (2) Local softening of the brain around the bullet, or abscess formation ; (3) The pulsations of the brain. The twisting or version of the bullet is probably caused by the following :—(1) Unequal softening round the bullet, allowing, for example, its base to sink before its nose ; (2) Uneven distribution of weight in the bullet itself, the posterior half being heavier than the anterior ; (3) The homogeneity of the brain tends to a general and even sinking ; but anything which interrupts this homogeneity, such as a leash of blood-vessels, might impede one part of a bullet, and so cause it to turn.

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[1] " Inter-relation between the Radiography and Surgery of Gunshot Wounds of the Head, " *Brit. Jour. Surg.*, 1917, July.
[2] Quoted by ROWLANDS and TURNER, *The Operations of Surgery*, 1915, i, 286. London.
[3] *Der Chirurgie des Gehirns*, Berlin, 1909.
[4] " Movements of Foreign Bodies in the Brain," *Arch. Radiology and Electrotherapy*, 1916, June.

SOME ASPECTS OF THE TREATMENT OF INFECTED WAR WOUNDS.

(From the Millicent Sutherland Hospital.)

By Captain O. G. MORGAN, R.A.M.C., Captain F. D. SANER, R.A.M.C., and Temporary Surgeon E. G. SCHLESINGER, R.N.

In any discussion of the treatment of wounds, and particularly of severe wounds, it has constantly to be borne in mind that few surgeons have had the opportunity of dealing with more than one aspect of the problem involved, and consequently any views expressed must to a very large extent be limited to that particular aspect. The passage of a wounded man from the front to a base falls roughly into three stages—namely, the front, the bases in France, and the bases in England,—and the treatment and outlook during these three stages are governed by such widely divergent conditions, that any argument from one to the other proves usually to be quite fallacious. It has seemed to us that in very many of the writings on the treatment of war wounds this fact has been, perhaps, partly lost sight of, and we wish particularly to limit our views to those matters of which we have some experience, namely, treatment at the base in France.

There can be no doubt that many of the divergent views which are held, and frequently and forcibly expressed, are due in part to the attempt to argue from facts observed in one place, to a purely imaginary set of conditions in another, and much that is still unsatisfactory in our treatment of the wounded would be helped by a greater fluidity and a freer intellectual communication between surgeons working at the different stages of the wounded man's journey. While evacuation is the key to the successful administrative treatment of the wounded, at the same time it often locks the door to successful surgery and surgical advance, and very often shares in the responsibility for bad results, to a far greater extent than is usually admitted.

Where so many cases have had to be dealt with by surgeons of differing schools, attention has naturally tended to be attracted by detail where principles were really in question, a state of things which has been accentuated by a certain bias taken on by discussions between the protagonists of the chief schools. So much has this been the case, that many articles which have appeared, and which at first sight appear to be entirely opposed to each other, prove, when dissected, to be based on identical lines of thought, which, however, run so tortuously through a mass of detail and test-tubes as to risk being entirely overlooked. In spite of this, however, certain general principles appear to us to be gradually emerging and assuming a definite place in the consideration of a new, and at times a difficult, branch of surgery. It is to these, as they apply to infected wounds of the bones, joints, and muscles at one stage of their course, that we would attempt to confine our remarks.

The trials of a wounded man during the first week of his existence as such are usually very great, including as they do the initial shock and loss of blood, transport from the lines through a field ambulance to the casualty clearing station and thence to the base, and a varying amount of surgical interference and septic infection. The first few days after his arrival, therefore, are largely occupied by sleep, and in removing from his mind and body the unpleasant impressions of life in the front line.

The majority of fractures arrive in splints useful for purposes of transport but not adequate for efficient treatment in hospital. As soon as possible, therefore, the wounded part should be immobilized on a suitable splint, and the patient consequently freed from pain. This, unfortunately, usually necessitates an anæsthetic, in many cases following rather closely on a previous one at the casualty clearing station.

The first function of treatment at a base hospital in France is to limit the spread of infection already present. For this purpose two measures are necessary—namely, adequate rest or immobilization, and the rapid elimination of all dead tissues from the wound. The former is secured by proper splinting, and the latter we have obtained by applying a neutral hypochlorite solution (Dakin and Daufresne) by Carrel's technique. As regards the wound, it is our practice to interfere as little as possible during the first few days. Acute conditions are, of course, dealt with, but as a general rule Carrel tubes are placed in position under the anæsthetic, if one is given, and intermittent irrigation commenced. The less surgery to which a patient is submitted at this stage of his infection, the better his outlook, since Nature's defences are as yet only in process of construction. Pain must be relieved, and it usually is by perfect immobilization; but if for any reason it persists, it must be dealt with by drugs.

It is often contended that the wounded with whom the army has to deal are fit men ordinarily; but it must be remembered that they have undergone a period of stress unheard of in a civilian patient, and consequently their resisting powers are very greatly lowered. The future of a wounded man varies directly with the amount and virulence of his sepsis, and cases which do not have a clean wound after a few days at the base should always be looked upon as serious. The great majority of the cases of compound fracture are infected, some slightly, some intensely, but all to a considerably greater degree than is apparent when they leave the clearing stations, a fact which is a good example of the necessary consequences of evacuation to which we have previously referred.

We propose to discuss the treatment of wounds under two headings: (1) *The part wounded*; (2) *The wound itself*; but it must be remembered that the two lines of thought are completely interdependent, and are in reality necessary corollaries the one to the other. It is, however, in the field of pure wound treatment that the great controversy has raged, where the reactionaries, in the persons of the antiseptic school, and the progressives, or the physiological school, have met in a conflict of opinions and experiments, and where the tactics of detail have tended somewhat to obscure the strategy of principle.

It is, perhaps, a natural attitude that, since the sepsis is caused by organisms, then, when the organisms are once destroyed, all will be well, and an equally natural hope to look to the various antiseptics for such a destructive power. The 'therapeutic co-efficients' and 'bactericidal efficiency' of the laboratory hold out such a dazzling prospect, that when the wound fails to become clean, the tendency is to blame some detail of substance or technique where principles are in reality at fault.

The physiological school, on the other hand, seem to have much weightier arguments on their side; and since their laboratory is that of Nature herself, and their experiments but adaptations of Nature's own, it is possible to feel a certain confidence in the truth of their principles, even if their detail is at times open to question. There can be very little doubt that the treatment of septic wounds which is most likely to promise success is that which most closely imitates Nature's own treatment, or which exaggerates it to meet the aggravated conditions present.

Just what Nature's method is, however, is none too easy a matter to determine, although many competent observers have been engaged in interpreting it. Sir Almroth Wright and his co-workers have carried out a most brilliant and careful research into this subject, and though the methods which they have based upon it have not met with the success which was expected, yet this detracts not at all from the value of their work. Approximately it may be said that, when dealing with an infected wound, the natural reaction of the body is to limit as rapidly as possible the depredations of the invading organisms by destroying the food on which they live, and at the same time to guard against their further invasion by setting up a strong zone of defence around the wound. The first purpose is accomplished by the liberation in the wound, from dead pus cells, of trypsin, which, by splitting up the protein of the dead tissues, deprives the organisms of their pabulum, and forces them to attempt their destructive activities against living, fighting cells. The second is secured by the speedy construction of a band of leucocytic infiltration, and, as a guard against the activity of the body's own agents, by an increase in the normal antitryptic activity of the serum.

We have here, then, the lines on which successful wound treatment can most probably be obtained; and if it be granted that the natural line *is* the most likely to lead to success, it is difficult to find a basis on which the antiseptic school rest their claims, other than the doubtful one of antiquity, or the purely theoretical laboratory qualities with which antiseptics in their modern reincarnation have been endowed.

That the rapid removal of all dead tissue is the best method of dealing with infection is well shown by the success which has attended the early excision of wounds, where, by their nature, complete excision has been possible. This method is, however, only of use in a very early stage, since, when infection is actually in progress, complete removal of all dead tissue and potential dead tissue is not possible.

In the neutral hypochlorite solution of Dakin and Daufresne, we have, however, a substance of very great proteolytic value, and at the same time one which is itself destroyed in the process, a fact which prevents its interfering in any way with the normal action of the tissue cells. Its action on

protein in solution is almost instantaneous, while on coagulated protein its action is many times more rapid than trypsin. It has of course a purely chemical bulk action, and naturally, in a wound where dead tissue is plentiful, must be many times renewed before its action can be completed. This object is achieved by the intermittent irrigation method of Carrel, by which the fluid is brought into contact with all parts of the wound at frequent intervals. It is perhaps unfortunate in a sense that in a test-tube this fluid is possessed of a high 'bactericidal' power. By thus attaining rank as an antiseptic, it has shared any criticisms of these substances, and has had its claims based on a fortuitous property which would appear to us, after considerable experience of its use, to play a quite secondary and relatively unimportant part in its action. The mere fact that within a few seconds after its introduction into a wound, the hypochlorite, as such, ceases to exist, should be sufficient to absolve it from the dubious merit of antiseptic action in a wound; while the fact, which will be discussed while dealing with the bacteriological control, that a smear taken from any isolated portion of dead tissue will still give a high bacterial count when the rest of the wound gives a low one, is further proof of its innocence in this respect.

This all-important proteolytic action of hypochlorite solution, which is responsible for its undoubted efficiency in the treatment of infected wounds, appears to have been very little insisted on, and it is at least interesting to note that Browning and his co-workers refer to it as "the disadvantage possessed by the solution of destroying dead tissues!" Just exactly the nature of the chemical change which occurs in the hypochlorite on contact with protein is obscure, but the proteolytic action undoubtedly goes on to the rapid formation of amino-acids. It would appear probable that along this line—namely, rapid destruction of dead tissues—lies the way to further advance in the treatment of wound infections; and whether future research shows ferment action or chemical hydrolysis to be the more efficient, there can be no doubt that the recognition of the essential nature of this process is of the greatest importance if progress is to be made in dealing with the problems involved.

Nature's second method of dealing with an infected wound—namely, the establishment of a zone of leucocytic defence round the wound—is best aided by the maintenance of absolute rest in the part wounded, and further, by a minimum amount of interference with the wound on the part of the surgeon. Very valuable work has been done by Major Sinclair and others in insisting on the need for effective immobilization in the treatment of infected wounds, and too much stress cannot be laid on the importance of this side of the matter.

Treatment of the Part Wounded.—In wounds of the extremities, whether complicated by fracture or not, it has been our aim to secure immobilization of the limb involved, and at the same time to preserve to the patient as complete a mobility of the rest of the body as possible. This has been secured by carefully splinting the limb, and then suspending the whole splint from overhead pulleys with accurately balanced counter-weights. Any movement of the patient in bed is then followed by the splint, without any disturb-

ance of the injured part, as is shown by the absence of pain. As Hilton points out, " every deviation from this necessary state of rest brings with it, through pain, the admonition that the patient is straying from the condition essential to his restoration ; " and with the exception of the presence of pus under tension, pain in wounds is in our experience almost always due to faulty immobilization.

To secure extension, except in certain particular cases to be referred to later, we have used almost entirely Sinclair's glue, which, if carefully applied, is most efficient, and will stand very severe strains if the area of traction is distributed over as wide a surface of skin as possible.

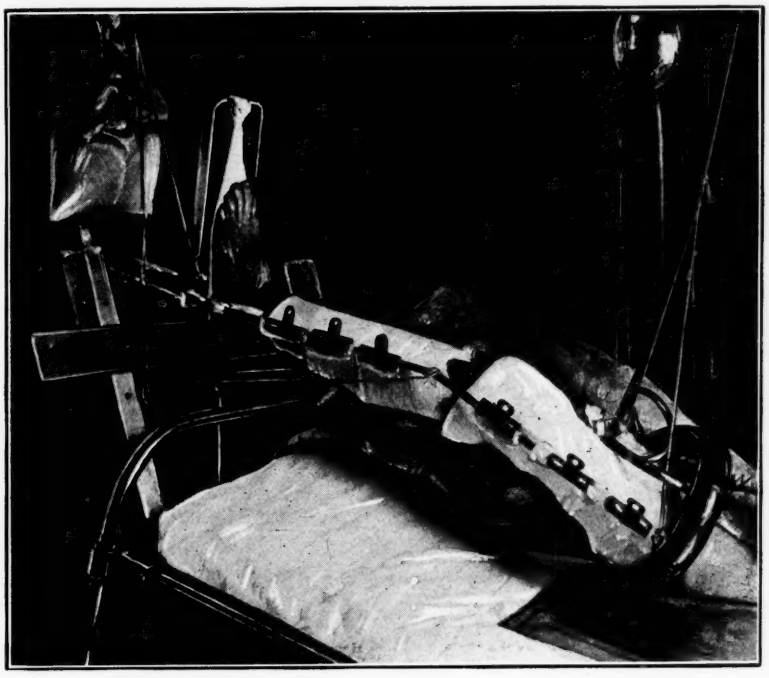

FIG. 349.—Compound fracture of the femur, showing glue extension and suspension.

In any splinting of the lower limb, one of the essential facts to be recognized is that the position of rest and equilibrium in the recumbent position is one of very considerable external rotation, as was pointed out many years ago by Sir Arbuthnot Lane. This fact at once renders unsatisfactory all those splints whose basis is a right-angled vertical foot-piece; a further objection to this form of splint being that it prohibits the normal inverted position of the foot if the splint is to be firmly applied, a point of considerable importance from the point of view of after-results. In dealing with fractures and wounds of the lower limb, we have used almost entirely the Thomas splint, either straight or bent, and suspended in extension on the Hodgen principle; the end of the bed being raised to secure counter-extension.

For fractures of the *Femur*, excepting those very high up, and for extensive thigh wounds, we have used a bent Thomas splint, with a metal archway fixed to the splint in the required position by Mead's strapping, and from which the foot is suspended by gauze glued to the sole of the foot. Extension is obtained by gauze glued to the leg and fixed to the end of the splint, while the whole splint is extended either by a running weight attached to its sides or by a forward position of the suspension pulleys (*Fig.* 349). In the majority of cases good position of the fragments can be fairly readily obtained, since the injury has usually damaged the longitudinal fascial compartments of the limb, and there is not the same incompressible resistance of effused blood, etc., which often renders the non-operative reduction of simple fractures so impossible (Arbuthnot Lane).

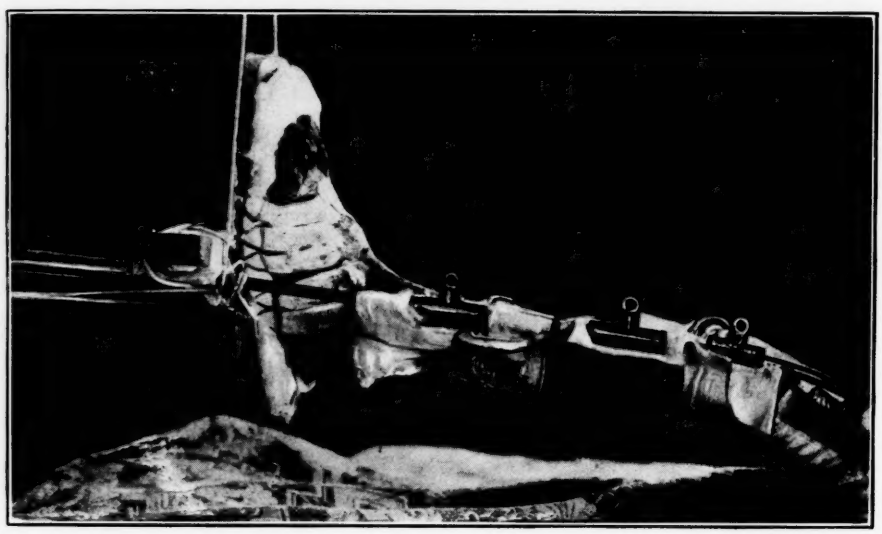

FIG. 350.—Compound fracture of the tibia, showing Sinclair's foot-piece in position.

In the matter of compound fractures of the *Tibia*, the ease with which perfect position can be secured varies very greatly with the type of the fracture. The long oblique fracture is always difficult, whereas the transverse or even the intensely comminuted fracture is on the whole readily dealt with. For the latter we have used a Thomas splint, with Sinclair's wooden foot-piece (*Fig.* 350), which consists of a flat piece of wood with serrated edges, so arranged as to be capable of adjustment with regard to the long axis of the leg in every direction. The foot is fixed to this foot-piece by tapes attached to metal triangles threaded on gauze strips glued round the sole. The foot, attached to the foot-piece, is manipulated until the position of the fragments is as perfect as possible. and is then fixed in that position by tightening the fly-nut and attaching the cross-bar to the end of the splint by tapes. By these means the lower fragment is efficiently fixed, and the position of the upper fragment should be maintained by strips of gauze glued to the sides of the leg and attached to the side bars of the splint, thus securing an

absolute immobility of the fragments relative to each other, while the whole leg in the splint can be freely moved.

For the fixation of corrected tibial fractures the foot-piece just described is almost ideal; but although a fair extension can be obtained with it, in our experience the very considerable pull needed to maintain the position of the oblique type of fracture is apt to lead to slipping of the gauze or blistering at the points of attachment of the triangles. For these cases we have used an oblong piece of perforated metal, glued to the sole between layers of flannel, and held in place by cross-bands of gauze running round to the dorsum of the foot. A wire attached to the middle of this piece of metal is fixed to the end of the Thomas splint. This foot-piece will readily sustain a weight of from seven to ten pounds for several weeks.

FIG. 351.—Compound fracture of the metatarsals, extended through the toes.

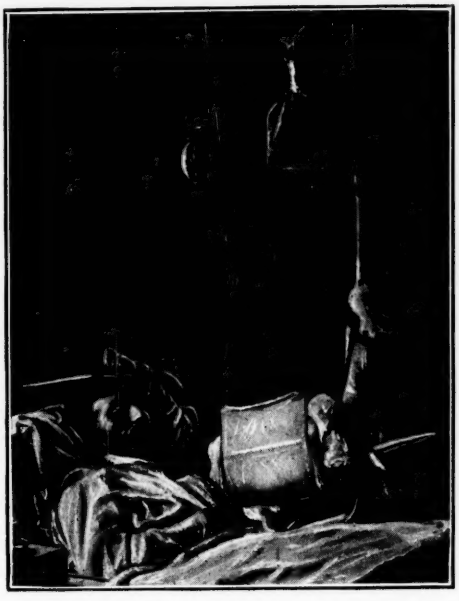

FIG. 352.—Compound fracture of the humerus, in suspension extension without splints.

At the same time the foot is suspended from an archway by gauze glued to the metal sole-piece.

Fractures of the *Tarsus* and *Metatarsus* have been dealt with by suspension from an archway by the toes (***Fig.* 351**), and, if in a Thomas splint, the leg has been kept in position relative to the point of suspension by gauze running from the leg to the bottom of the splint.

Fractures of the *Humerus* we have treated, as a general rule, with the elbow flexed to a right angle, and by methods varying with the position of the fracture and the wounds.

In fractures of and near the head of the humerus, we have found as a rule that a good position is best maintained without a splint, by

merely placing the forearm in a sling, the elbow being fixed to the body by bandages and strapping.

Fractures of the shaft of the humerus, in its middle two-thirds, have been treated in one of two ways, depending on the situation of the wounds. In cases where these are in front or lateral, or in a through-and-through wound, we have used a form of suspension extension without a splint (*Fig.* 352). Glue is applied to the front and back of the forearm, and gauze strips are fixed to it, while, similarly, gauze strips are glued to as great a surface of skin over the lower fragment of the humerus as possible. A mackintosh sling is applied over the dressings round the fracture, and suspended by a cord, which, running over two pulleys, has its other end attached to the gauze glued to the forearm. The necessary weight to secure an accurate counter-balance is attached to the cord between the pulleys. The gauze from the lower end of the arm is fixed to a cord running over a pulley at the end of the bed, to which the required extension weight is attached. By this method free movement of the arm as a whole is permitted without any disturbance of the fracture, and at the same time movements of pronation and supination, and of the fingers, can be freely carried out by the patient from the first.

FIG. 353.—Double compound fracture of the humerus, in bent Thomas splints.

This method is unsuitable for patients with extensive wounds of the back of the arm, or where the extent of the skin involved proves too great for its application. In these cases we have used an arm Thomas splint, bent at a right angle, and with the angles of attachment of the ring altered to fit over the point of the shoulder. When this splint is suspended at the level of the shoulder, the posterior wound becomes external, and is therefore readily accessible for purposes of dressing (see *Fig.* 353, where two of these splints are applied to double compound fractures). Extension is obtained by using the forearm as a lever. Gauze glued to the forearm above the wrist is fixed to the internal bar and forms the fulcrum, while gauze glued to the upper third of the forearm and pulled to the external bar forms the weight, thus exerting traction in the length of the arm. In suspending this splint, the centre point of suspension should be external and in front of its centre, thus preventing any unpleasant pressure of the ring round the shoulder.

Fractures of the *Forearm* have been treated either on this right-angled

Thomas splint, with the upper fragment fixed to the splint and a weight acting on the lower, or by a form of suspension extension tray (*Fig.* 354). This

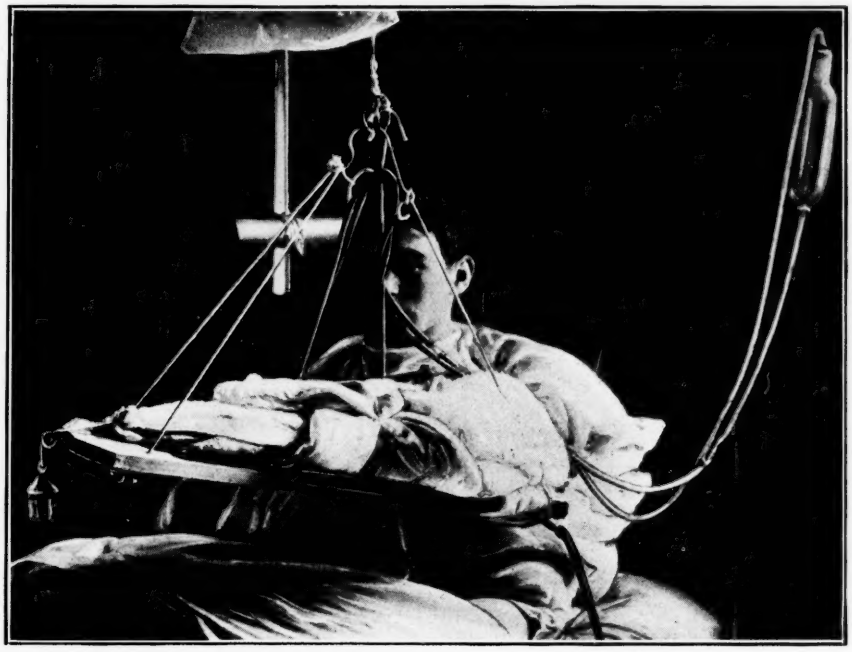

FIG. 354.—Compound fracture of the radius and ulna, on suspension extension tray.

consists of a metal tray from which a drainage pipe runs, and which has a wooden upright, against which the upper arm rests, to serve as counter-

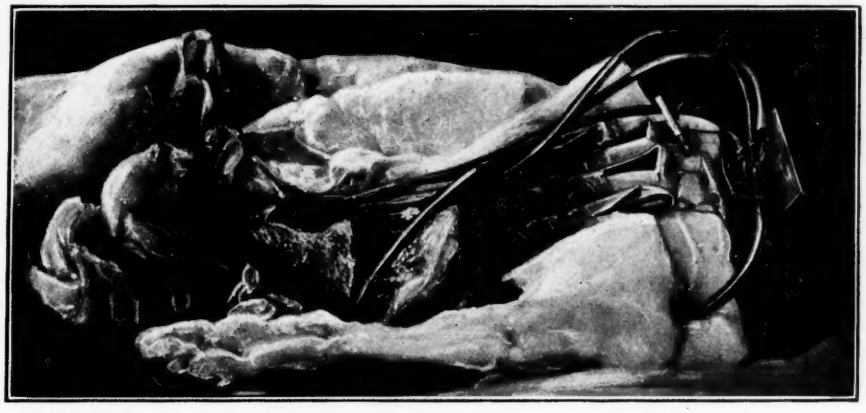

FIG. 355.—Compound fracture of the carpus, on suspension tray showing finger extension.

extension. The wooden attachment runs forward under the tray, and has at its end a pulley over which runs a cord, taking extension either from the

lower forearm or the fingers, according to the nature of the wound. In certain fractures of both bones a wooden side-piece with straps has been added, so that the forearm can be treated in three-quarter supination. The whole apparatus is counterbalanced in extension, and the drainage tube is connected to a bottle at the side of the bed, thus avoiding any wetting from the solution introduced.

In wounds of the *Carpus* and lower third of the forearm this splint has also been used, usually with a wedge attachment at the end to secure dorsiflexion of the wrist (*Figs.* 355, 361). In these cases extension has been obtained by attaching glued glove-fingers or strapping to the sides of the fingers, and running them by a kind of wood gearing to one central pull. This

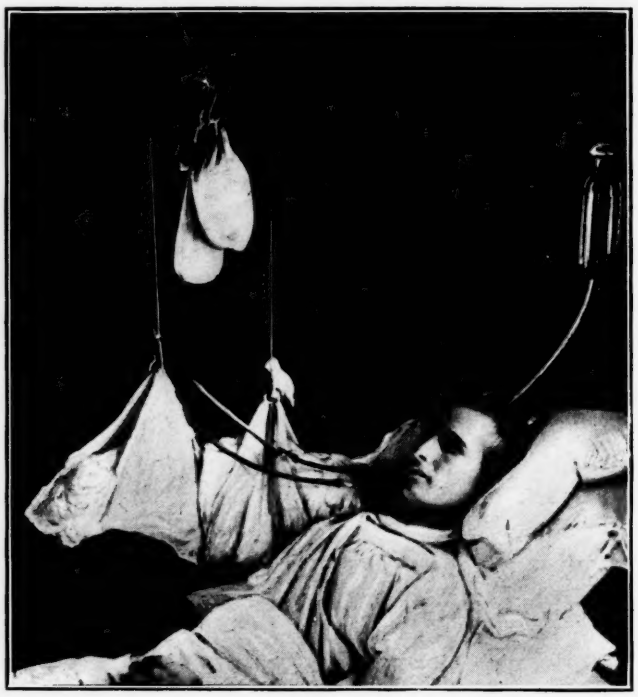

FIG. 356.—Compound fracture of the scapula, showing arm slings.

secures an even distribution of strain, and maintains the fingers in good position (see *Figs.* 355, 361).

In cases of fractured *Scapula* we have found œdema of the arm a troublesome consequence of treatment with the arm at the side, and have been in the habit of suspending the arm at shoulder-level in counterbalanced slings (*Fig.* 356).

In suspending these various splints, we employed at first a form of light scaffolding fitted over each bed (*Fig.* 357), as in use at the American Ambulance at Neuilly; but later we have had fitted inside the hut a permanent superstructure to which cross-bars can be attached in any position, designed for us by Mr. Douglass of this hospital (*Fig.* 358). The advantages of the

FIG. 357.—Ward showing scaffolding over each bed.

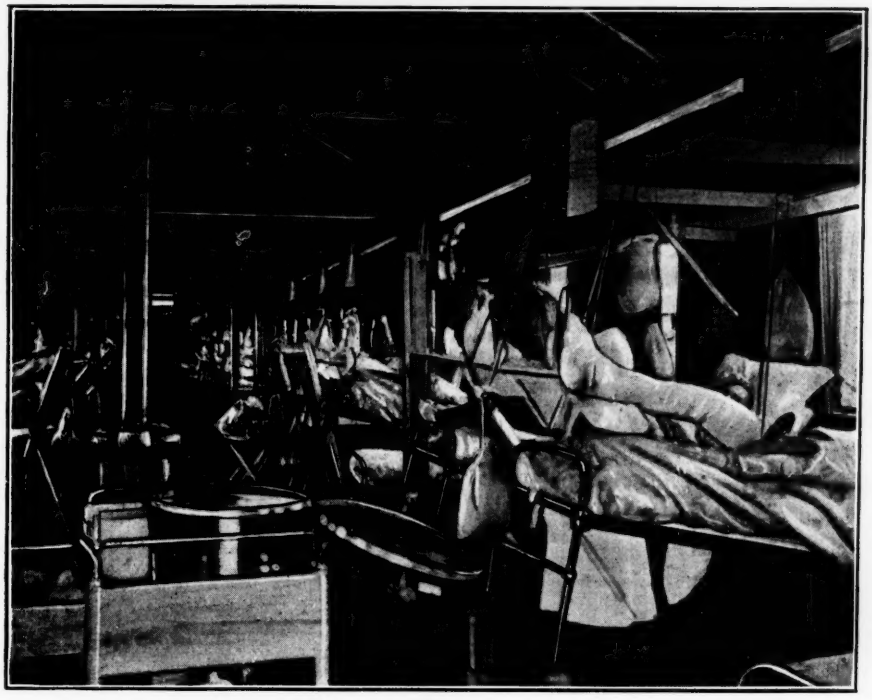

FIG. 358.—Ward with permanent superstructure to which cross-bars can be attached as desired.

suspension splint from the point of view of the patient are obvious, since his range of movement in bed is almost unlimited; while, from the nursing point of view, these otherwise helpless cases can be readily moved and lifted without any fear of injury or pain to the wounded part. That they require a certain amount of care and time in fixing is no doubt true; but the greater comfort, rest, and accessibility obtained adequately compensate for this.

Joint Injuries.—In the mechanical treatment of these injuries, the main object has been to arrange the limb in such a position as to obtain as speedy as possible a penetration of the irrigating fluid into all parts of the joint involved. Extension is here the prime need, and where extension is really efficient, immobilization of the injured parts, i.e., the joint surfaces relative to each other, will follow automatically.

In infected wounds of the *Knee-joint*, where a natural arthrotomy was in existence or where a surgical arthrotomy was performed, we have used the metal extension stirrup of Finochietto, which passes over the superior surface of the os calcis close in front of the tendo Achillis, and to which very heavy

Fig. 359.—Compound fracture of the femur with buttock wound, showing Finochietto's extension stirrup applied.

weights can be attached without either pain to the patient or injury to the tissues (*Fig.* 359). The region of entrance and exit of the stirrup is covered with copious sterile gauze bandages, which also serve to maintain the relative position of the stirrup, and to prevent any tendency to calcaneus. We have also used the stirrup in the treatment of certain compound fractures of the femur high up, with very good results. Dr. Chutro and others have used it almost exclusively in the treatment of all fractures of the thigh and leg; but in our opinion the more perfect immobilization of the Thomas splint outweighs the better extension obtained by the stirrup in these cases.

In this matter of securing extension in cases of infected knee-joint wounds, it has been argued that a pull of many pounds can be obtained by gauze glued to the sides of the leg. Our objection to this method is that only a part of such pull is actually felt at the joint, since, owing to the surface of application being the skin, much of it is dissipated by transmission to the skin or fascia of the thigh, i.e., above the joint to be extended.

Elbow-joints have been treated on the suspension extension tray, by which means very good access to both the radio-humeral and humero-ulnar joints is obtained (*Fig.* 360). By this method the joint is flexed to about a right angle, and it has been found that this gives better access to the joint cavity when the irrigation or flushing treatment is being used, than when the elbow is extended.

Wrist-joint wounds, of which we have had several, have been treated in the same way, extension being obtained from the fingers (*Fig.* 361), a wedge attachment being fixed to the tray if dorsiflexion is desired. These cases have been particularly favourable, in spite of the fact of their frequent

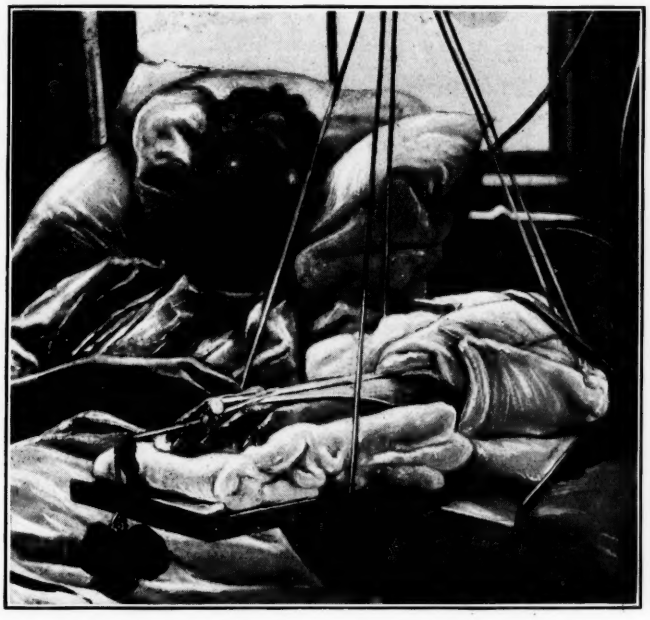

FIG. 360.—Wound of the elbow-joint, showing the adaptation thereto of the suspension extension tray.

complication by carpal and metacarpal fractures. Both here and in the ankle there is a tendency to spread of infection along the tendons, and this must be carefully watched for ; it would appear to be due to the fact that dead tendon tissue is not readily hydrolysed, and therefore serves as a nidus for further infection.

Ankle-joints have proved difficult, since they are so frequently complicated by compound fractures of the tarsus ; but in those cases where the skin of the sole is uninjured, a very good separation can be obtained by using the metal sole-piece described above in dealing with oblique fractures of the tibia. A point of great importance in these cases is to obtain a very considerable degree of inversion of the foot, both from the point of view of after-results and of immediate treatment.

We have not had sufficient experience of wounds of the hip and shoulder-

joints to enable us to arrive at any definite conclusions as to their most efficient fixation.

Treatment of the Wound Itself.—Our object here, as pointed out above, has been to destroy as rapidly as possible all dead tissues in the wound. This we have achieved by intermittent irrigation through Carrel's tubes with the hypochlorite solution of Dakin and Daufresne. The general technique of this treatment is now widely known; but as the detail of its application is important, there are some points on which we would lay emphasis.

The first of these is that the desired object of reaching every part of the wound with the fluid can only be obtained by a careful and proper adjustment of the tubes. As a general rule, for the depths of a wound, tubes with a

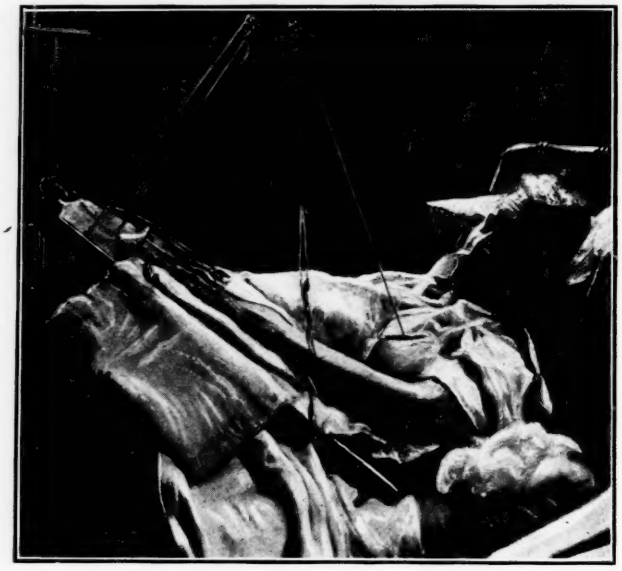

FIG. 361.—Wound of the wrist-joint, showing gearing extension from the fingers.

few holes are used, since the pressure of flow required is great; while for the surface, where a low pressure is called for, tubes with many holes are employed. Deep and surface tubes should be connected to different supply reservoirs, otherwise the greater proportion of the fluid is necessarily distributed to the surface.

A second point of importance is that the fewest possible number of tubes which will distribute the fluid efficiently should be used. Drainage, which is of equal importance with the irrigation, is then not impeded. It is unfortunately common to see a number of tubes pushed closely together into an opening, thereby acting as an efficient cork, but as little else. Often, again, a tube is seen firmly wedged, or even sewn, into a narrow sinus, where the forcing through of fluid must tend to open up new fascial planes to infection.

Once the tubes have been properly placed, they need not be touched until

they become misplaced or blocked, a matter of time varying up to seven or even ten days.

In dealing with cases of compound fracture, it is advisable, where possible, to verify by a radiogram the fact that the tubes reach to the spaces between the fragments.

It has been the practice here to carry out irrigation with the solution two-hourly. The question of continuous versus intermittent irrigation has been much discussed, and though at first sight the continuous would appear the preferable method, there are many objections to its use. In the first place, from a practical point of view it is almost impossible to ensure the fluid reaching all and every part of the wound by any form of continuous drip, an object which on the other hand is obtained readily by the sudden flush of the intermittent method; this has the additional advantage of sweeping before it the contents of the wound cavity, and thus corresponding to a two-hourly dressing. Again, since the hypochlorite is destroyed within a few seconds after contact with protein in solution, the natural tryptic and phagocytic reactions of the wound are undisturbed, and Nature is enabled to lend her valuable help in cleaning the wound in the interval between the flushings. In the early stages of an infected wound where dead tissue is plentiful, hourly irrigation is preferable.

There is no danger of burning or irritation of the surrounding tissues so long as there is pus in the wound. When, however, sterility approaches, and dead tissues disappear from the wound, the surrounding skin must be carefully vaselined to protect it from the action of the hypochlorite.

To minimize as far as possible the disturbance of dressings, we have avoided the use of wool and bandages, and have used instead large pads made of layers of wool between gauze, and specially shaped and sewn to fit the different anatomical regions. These soak up the discharge and overflow of fluid to a certain extent; the remainder runs into large metal trays placed under the limb or body, and drains into a bottle beside the bed. These large dressings must be changed at first perhaps every other day; but as the wound cleans, it is possible to leave them up to a week or more, a matter of great importance when the disturbance of holding and bandaging a fractured limb is remembered. As a routine, the wounds are dressed every other day; but this dressing is merely a matter of changing the gauze and seeing that the tubes are pervious and in position. In painful cases, such as guillotine amputations, the dressings may be left untouched in perfect safety for a week or ten days, a great comfort to the patient.

SURGICAL TREATMENT.

In addition to the lines of treatment sketched above, ordinary surgical principles as they apply to infected wounds must be observed; but it has appeared that certain modifications of some of the usual procedures are desirable.

The provision of efficient drainage is of course as essential under these conditions as under any others, and a complete opening up of the original wound, and well-placed counter-incisions, are all important, particularly in

the case of compound fractures. All pockets and portions of the wound must be made freely accessible to the irrigating fluid, since an area of dead tissue in some recess where it is not reached and therefore not dissolved by the hypochlorite will, at the least, continuously reinfect the wound. As far as possible use is made of anterior incisions, to facilitate both dressing and splinting, but in almost all compound fractures—of the femur, at any rate—a free approach from two directions is necessary.

In the early stages of acute sepsis we would advocate the least possible manipulation of limbs in search of hidden or pocketed pus, as in the majority of cases, if the immobilization is good, a barrier will be formed against any general spread of infection, and pus, if it is formed, will be local in site and readily dealt with when the moment arrives. The early exploration of such doubtful wounds with instruments or fingers would seem to serve no useful purpose; and always provided that incisions and counter-incisions are well placed and free, and splinting sound, it would seem both safe and desirable to wait for the pus, if present, to announce its formation as a fluctuating abscess, or by a leak into the general cavity of the wound. Any spreading cellulitis or an acute abscess must of course be dealt with, preferably in bed, under gas, to ensure a minimum of movement to the affected part.

As a general rule cases have been kept at this hospital until they have advanced to a stage where any serious complication is unlikely, but in very few instances until they have run their full course. Since the efficiency or otherwise of any early surgical treatment can only ultimately be judged by end-results, any expressions of opinion as to such treatment must be tentative, and subject to correction where results prove bad.

Fractures.—Immobilization has already been discussed; in addition, as perfect as possible a position of fragments must be obtained, and obtained early. There can be no doubt that the better the alinement of the limb—by which is meant the position not only of the bone fragments, but of muscles, nerves, vessels, and lymphatics as well—the more rapid will be the diminution of pain and sepsis. Major Sinclair has most ably demonstrated the importance of this principle, and we wish to acknowledge our indebtedness to him for many ideas and suggestions.

In dealing with a large number of compound gunshot fractures, the problem of what to do with loose or partially loose fragments of bone assumes an even larger aspect than in civil practice, and considerable divergence of opinion exists as to the best line to be adopted. There is no doubt that by removing all loose pieces, a more rapid sterilization, and possibly a quicker closure of the wound, can be obtained. Those who favour this plan have as their object the conversion of a compound into a simple fracture as soon as possible with a minimum of sepsis, and hold that any loss of substance needing repair can be dealt with later. A certain confidence which the above described line of treatment has given us in its ability to control the spread of infection in compound fractures, has induced us to lean towards the opposite extreme. Completely detached fragments are of course removed, but any piece bearing any attachment to the tissues has been left, and it has often been found that such pieces become firmly attached later, and play a most important part in

the deposit of callus along the line of the bone. Occasionally removal of a piece of bone may be necessary to obtain more efficient drainage, but this should be avoided whenever it possibly can. There can be no doubt that by this attitude the probabilities of obtaining a better bone anatomically are greater. In the lower limb, where function and structure go hand in hand, this is perhaps more important than in the upper limb, where a rapid control of sepsis and a speedy resumption of movement are all-important.

The question of completely closing a wound in cases of compound fracture is very open to debate. Though there can be no doubt that where it is successful it prevents to a very great extent troublesome adhesions between bones, muscles, and skin; yet, excepting in certain very simple cases, the bacteriological control of the bony interspaces must always be, at the best, uncertain, and the procedure, therefore, always risky. The gain of closure in such cases has not seemed sufficient, except in a few instances, to counter-balance the risk; and, in addition, the moment for evacuation has usually arrived when the question of suture comes under serious consideration.

Wounds of Joints.—Much attention has been paid during the war to the treatment of infected joint wounds, and although certain methods have been advocated for a time and have then been dropped, yet on the whole very considerable advance has been made, and many limbs can now be saved which would have been lost in the past. Very many wounds of joints, more particularly perhaps those of the knee-joint, that have been washed out and closed as a primary measure at the casualty clearing station, have reached this hospital; and while in some cases suppurative arthritis has intervened, up to two weeks or more after closure, the results have been remarkably good on the whole. In contrast to what is the case in compound fractures, everything is to be gained by such an early closure of joint wounds, while if they are carefully watched, the danger to the patient is not greatly increased by this procedure. In successful cases an almost perfect joint rapidly results; while in cases that fail, the failure is not greatly aggravated by the attempt at perfection. Where suppurative arthritis does occur, the problems to be faced are mainly concerned with the mode of access to the joint and the method of extension, the latter of which has been discussed above. The question of access must be considered in connection with the particular treatment of the joint cavity used; it differs somewhat where irrigation by the proteolytic hypochlorite solution is employed, from that suitable where simple drainage alone is relied on, since in the former the flush of irrigation negatives the stagnation effect of gravity which must be dealt with in the latter.

In the case of the *Knee-joint*, both treatment and prognosis seem to depend upon whether the infection is limited to the part of the cavity anterior to the crucial ligaments, or whether the posterior portion of the joint is involved as well; and there can be no doubt that the outlook in the latter case for both limb and life is much more serious.

The first essential in the treatment of all these cases is extension, and the earlier this can be applied the more hopeful the result. Such an extension

must be of sufficient force to ensure an actual stretching of the ligaments, and thereby a separation of the joint surfaces. We have secured this pull by the use of the stirrup described above, which seems to have a very definite value in the treatment of these cases.

In early infections repeated aspirations may be tried, but should not be persisted in in the face of an unfavourable bacteriological report. The importance of such an examination, both as regards immediate treatment and ultimate result, has been rightly insisted on by Lazarus Barlow in a very instructive article.

When arthrotomy is decided upon, it must, to be effective, give free access and enable the irrigating fluid to reach all parts of the joint involved. Incisions on either side of the ligamentum patellæ enable the anterior part of the main joint, and the articulation between the patella and the femur, to be reached, while in addition a small incision at the topmost part of the supra-patellar pouch is usually necessary to control this cavity efficiently. In cases which run a favourable course, the irrigation tubes can be withdrawn to the level of the capsule after a few days, and movement, as far as is allowed by the extension, can be encouraged (a great advantage of the stirrup). If the infection does not tend to come under control, the possibility of a post-crucial spread must be borne in mind, but any early extensive posterior incisions are to be deprecated. If sufficient extension is maintained, it is usually safe to allow pus to point behind before interfering. By this attitude the dangers of opening new paths to infection are lessened, and much anatomical disturbance avoided, while the possibility of the infection being in reality still ante-crucial is given every opportunity of declaring itself.

In the *Elbow-joint* the case is rather different, in that the majority of wounds of this joint are complications of fractures of the bones entering into its formation, and therefore the early treatment by washing out and suture is seldom possible. In many cases the incisions for drainage of the fracture can be made to serve the same purpose for the joint, but in others separate incisions are needed, and here again the provision of access to all parts of the joint is the main essential. In these cases, and in those in which a deliberate arthrotomy is required for a suppurative arthritis complicating fractures round the joint, we have used a longitudinal incision over the head of the radius in preference to the more usual posterior incision, and have treated the joint in flexion rather than in extension. This incision not only gives very good access to the elbow-joint proper, but in addition brings the orbicular ligament under the eye of the surgeon, and allows early interference in case of infection before the all-important radio-ulnar joint becomes disorganized. This incision is of course only efficient in the flexed position of the limb; and since in this position it is anterior, it presents also the advantages of allowing adequate flushing with the hypochlorite solution and ready accessibility for dressing purposes. With this method, results on the whole have been remarkably good; and although in many cases no doubt arthroplasty or excision may ultimately be needed to secure mobility, the control of the sepsis has not called for it in any of our cases.

Excision has had its claims urged by several surgeons as a primary method in dealing with infected elbow-joints; but it is difficult to see what

advantage this operation has to offer, when the fact that infection can almost always be controlled without it is balanced against the very definite and serious drawbacks of the method when used during the stage of acute infection. The whole question of excision of joints is shrouded in considerable mystery, owing to the differing conditions of the wounds and of the objects sought by the operations. With excisions performed for orthopædic purposes we have no concern, since this is a matter entirely beyond the sphere of base hospital work in France; but many surgeons both in France and in England advocate excision for purely drainage purposes, or, in other words, as a conservative operation, both in elbow and knee-joint injuries of a severe type. While admittedly these cases are some of the most difficult to control of any infected wounds, it would seem doubtful whether excision, at any rate in the knee and elbow, has any advantages to offer. If really efficient drainage is to be secured, a very considerable margin of bone must be sacrificed, a fact which, in the knee more particularly, makes the end-results of these cases problematical in the extreme. In addition, the whole zone of defence of the patient is disturbed, and an organism already at the extreme limit of resistance is suddenly brought face to face with an entirely fresh bacterial attack which it is quite unprepared to meet. A further disadvantage of excision must always be that the margin in these cases is small, and that should improvement not occur very quickly after this operation, amputation will be called for, and the patient be forced to submit to two extensive surgical measures within a very short space of time.

On the one hand, then, we have the less active treatment, of simple drainage and hypochlorite irrigation, with, as its best result, a useful limb, and, as its worst, amputation when the margin of safe delay is exhausted. On the other hand we have excision, with, as its best result, a limb the usefulness of which—bearing in mind the free removal of bone and the prolonged drainage—is problematical, and, as its worst result, amputation in the face of a margin of safety gravely curtailed by a previous extensive operation. In the case of the elbow-joint in particular, the great readiness with which these cases have come under control has given us no need to take the question of excision into serious consideration, at any rate as a means of controlling infection.

Secondary Amputation.—This is probably one of the questions needing a better judgement and more careful weighing of pros and cons than any other which a surgeon at a base hospital in France has to deal with, That in each case there is a certain margin of safety, which dare not be overstepped, in attempting to continue conservative treatment, is undoubted, and the recognition of the moment when this limit is reached is often fraught with great difficulty. It is just one of those points which must be considered entirely afresh in each individual case, and a series of successfully conserved cases on the one hand, or of failures on the other, must not be allowed to weigh unduly in deciding on the treatment of any particular individual. The problem consists in balancing the chance of losing or shortening lives by prolonged attempts to save limbs, against that of sacrificing limbs which might have been saved in the end. Now, while the instrument makers have no doubt

advanced greatly in the design and construction of artificial limbs, yet at the best such a limb is a poor thing, putting the patient at a disadvantage in his struggle for existence, a fact which is often not sufficiently recognized when the question of amputation is being considered. Some of the most unsatisfactory results of conservative treatment, provided they are painless, are often better than the best artificial limb; and while this is true of the lower limb, it is doubly so of the upper. Another fact to be borne in mind is that the scope of orthopædic surgery to-day is such that, until it has had its chance, it is practically impossible to condemn any limb as useless.

Bearing these points in mind, we have on the whole tended towards extreme conservatism; and although in one case death may have been due to this attitude, there are many others in which quite sound limbs have been saved which at one stage appeared unsaveable. In a large series of compound fractures we have performed 12 amputations, of which 8 were for shell wounds of the tarsus and ankle-joint (one being for acute infective gangrene); in these cases the fact that has helped to influence us in not continuing conservative treatment unduly is the very dubious end-results which could be obtained in these severe tarsal fractures; and it has been held better to seize the moment when a low amputation is safe, rather than run the chance of losing considerable length of limb in trying to save a foot of very doubtful value. Of the remaining four, two were suppurating knee-joint wounds, in one of which death resulted (the case referred to above). A third was an arm with a disorganized elbow-joint and a wound of the forearm destroying the ulnar nerve; this was amputated on the occasion of the third secondary hæmorrhage. The fourth case was of a different type, being an amputation through the thigh for spreading gangrene following a traumatic aneurysm of the posterior tibial artery; in this case death followed from acute toxæmia.*

Wounds of Muscles, uncomplicated by bony injury, are much less difficult to deal with; but by their frequency, and the disability which may result from adhesions or massive scar-formation, they require careful handling. Rest is just as essential a part of the treatment of these wounds as of that of compound fractures, and this is particularly the case where tendon sheaths are laid open to the spread of infection. By the use of hypochlorite, such sloughing and suppurating muscle wounds can be freed of all dead tissue in a period of a few days; with the possible exception that dead tendon tissue, being difficult of hydrolysis, needs removal with the scissors. All these wounds can be wholly or partially closed when sterilized; and there can be little doubt that the more extensive use of this procedure, under the effective control of bacteriological examination, would ensure the avoidance of much disability and many painful or contracted scars. In deep or through-and-through wounds of a muscular part such as the thigh, it occasionally happens that suppuration and a high bacterial count persist beyond the usual time. In these cases, if no foreign body is present, it will almost invariably be found on exploring the wound that a portion of dead tendon tissue, consisting of

* This case was not one of compound fracture. It is included here for the sake of completeness, but will not be found in the appendix of cases.

an aponeurosis or tendinous intersection, has resisted solution and acted as a base for continued bacterial attack. If such portions are removed, the wound will be found to come quickly under control.

There is a certain type of patient suffering from multiple muscle wounds, none of them necessarily severe, in whom a curious lack of reaction shows itself. He appears to have lost all power of response to infection: he does not produce pus, nor is there any evidence of the formation of a reacting inflammatory zone. Such a patient tends to go down hill steadily, and die. These cases present a pathological problem of great interest, in that it is difficult to understand why 'shock' should interfere with what must be entirely a chemical reaction; and again, if 'shock' *is* responsible, it is not clear why it should be so severe in a patient whose total wound area may be considerably less than that of a vigorously reacting single-wound case.

COMPLICATIONS.

The prognosis of any severely infected wound can seldom be predicted with any certainty when it is first seen, depending as it does on so many factors, such as the resistance and reacting powers of the patient, of which we have at present no scientific measure.

One of the most fatal complications which can occur in the course of an infected wound is a *septicæmia*, and there would appear to be no indication either in the site or nature of the wound, or in that of the infection, from which warning of its onset can be obtained. Just what the conditions are which are capable of upsetting the balance between the defences of the body and the attacking organisms, so as to enable the latter to obtain undisputed access into the general circulation, is not very clear, but there are certain factors which undoubtedly tend to help such an occurrence. One of the most important of these, under certain conditions, is undoubtedly inefficient drainage. Although this may lead to spreading cellulitis and abscess formation in a limb under any conditions, it would appear that where rest is absolute, the body can usually prevent any complete breaking through of its defences; but where faulty immobilization, especially when subject to the stress of transport, is added to inefficient drainage, the dangers of a septicæmia would appear to be considerable. This is one of the great disadvantages to be urged against the complete early closure of wounds, either complicated with fractures or without, under circumstances where early and frequent transport is a necessity of the patient's future, when no absolute certainty can be felt that infection is completely mastered. The same risk attends any extensive surgical interference during the stages of acute infection; and since with rigid immobilization the occurrence of a general infection is almost unknown, it is a great deal safer to wait until fluctuating pus calls for a purely local intervention, than to make extensive incisions on the ground of local inflammatory signs, with the risk of a fatal septicæmia to follow.

In addition to septicæmia, another severe and at times dangerous complication of infected wounds has to be feared, namely, *secondary hæmorrhage*. At first sight, since the avowed object of using hypochlorite in the treatment

of infected wounds is the rapid solution of dead protein, it would seem probable that secondary hæmorrhage should be commoner with this treatment than with others, since blood-clot is very readily dissolved by the fluid. But in a large number of cases so treated there has been no undue frequency of this complication, though it has occurred in a certain number: it seems probable, however, that in the latter the secondary hæmorrhage was in no way due to the hypochlorite, since when it did occur it was in wounds intensely septic, where pus—that is, protein in solution—was plentiful, and in such wounds the hypochlorite as such is destroyed within a few seconds after its introduction, long before it could have any action on the blood-clot. It has, however, been our practice to pay particular attention to bleeding points after any operative measure where bleeding occurs, and, in addition, not to introduce the hypochlorite solution for at least twelve hours after operation, so as to diminish the chances of oozing.

The fact that secondary hæmorrhage, as such, occurs almost invariably in extremely septic wounds, and especially where the sepsis is tending to spread, leads one to believe that inefficient drainage is mainly concerned in its causation, though the intense general prostration in proportion to the amount of blood actually lost points rather to a more obscure origin.

MODE OF ACTION OF HYPOCHLORITE SOLUTION.

At the present moment there is still considerable uncertainty both as to the mode of action of the hypochlorite solution and the exact nature of its break-down products. Further, very different results have been obtained by different observers as to its direct 'bactericidal value,' especially in the presence of pus or serum. Our own view is that as a pure bactericidal agent—in the sense of *directly* destroying micro-organisms—its action is unimportant, and that its undoubted value in the treatment of infected wounds depends on its power of destroying dead tissue, and so depriving the infecting organisms of their pabulum.

Experiments made to determine the action of a 0·5 per cent hypochlorite solution on coagulated albumin, gelatin, albumin in solution, and dead tissue, showed that the solid protein was dissolved, and the protein in solution altered. This alteration consists in an hydrolysis of the protein, which appears to be complete, and the various stages of the formation of alkali albumin, proteoses, peptone, and lower products can be followed. The action is a bulk action, and since the hypochlorite is itself decomposed in the process, the amount to be used bears a direct ratio to the amount of protein to be destroyed; this fact explains the apparent failure of Dakin's solution in Sir Almroth Wright's 'artificial slough' experiments. As an example: In a solution containing 5 per cent egg-white and 0·5 per cent hypochlorite, no protein, proteoses, or peptone could be detected after eight hours' incubation, although all these substances could be found at varying stages in the experiment.

Muscle, catgut, silk, and cotton were all destroyed readily *in vitro*. This is not the case, however, with bone. If a weighed piece of bone with soft tissues attached is submitted to the action of hypochlorite solution, there is at first a slight gain in weight, after which the weight steadily diminishes until

the soft tissue is completely dissolved, when the weight remains constant under further treatment. Although the ready solution of ligature material would appear at first sight to present a danger in the use of hypochlorite in wounds, this is not so in practice, since the amount of protein in solution present in a wound is sufficient to neutralize the hypochlorite as introduced. This fact also accounts for the absence of any injury to the living tissues when the hypochlorite is introduced under these conditions, a fact well shown by the normal appearance and phagocytic activity of the white cells as seen in the smears examined from the wounds under treatment.

In direct proportion as the dead tissue disappears, the organisms, as shown by the bacterial controls, diminish in number, since most organisms need at any rate polypeptides for their growth, and these are hydrolysed into simpler products by the hypochlorite. Wright points out that the streptococci and the staphylococci are the only organisms able to assimilate the protein in serum, which he speaks of as being 'protected' from digestion by the antitrypsin of that fluid. In this connection it is interesting to note that a study of the nature of the flora of wounds treated here by hypochlorite shows that the coliform and sporing bacilli disappear first, then *B. Welchii*, and that the streptococci and staphylococci are the most persistent. An exception, however, is *B. pyocyaneus*, which has sometimes made its first appearance when the wound was relatively free from other organisms and was clean, and the suggestion is made that this organism may be able to develop in the absence of peptone or polypeptides.

BACTERIOLOGICAL CONTROL.

Films from the most infected part of each wound have been prepared and examined every other day by the method worked out at Dr. Carrel's hospital, and the number of organisms per field of the microscope is entered on a chart (*Fig.* 362), and forms an efficient guide to the progress of the wound. At the same time, in examining these films, the type of organism is also noted, as well as the nature of the cells, particularly the relative number of mononuclears, and their condition of preservation, phagocytic activity, etc. While such a control can by its nature only be approximate, it is found in practice to be most efficient, both in relation to the progress of the wound, and to the moment for suture, if that is aimed at. If the hypochlorite is reaching all parts of the wound, and in consequence dead tissue is being evenly eliminated, the chart will be found to have a steady downward tendency. The persistence of a high bacterial count, provided there is no fault of technique, almost always points to the presence of a foreign body of some kind, or to the fact that all parts of the wound are not being reached by the solution.

In the course of the routine examinations here, the tetanus bacillus has been found in a certain number of cases, and although in none of these has tetanus developed, yet the recognition of this organism is an indication for active prophylaxis.

As regards the cell content of the films, at first only polymorphonuclears are seen; but as 'sterilization' proceeds, the large lymphocytes and endothelial cells come into evidence, until they may number one to every six or

seven polymorphonuclears. A large percentage of mononuclears, however, is sometimes seen when there are still many organisms, and vice versa; but in general it may be said that the appearance of mononuclear cells is a favourable indication.

On the lines described above we have attempted to carry out a system of treatment based on the principle of assisting Nature in the process of repair; and it is because we have been fortunate in having a number of severely infected cases to deal with under conditions allowing of observation in some detail,

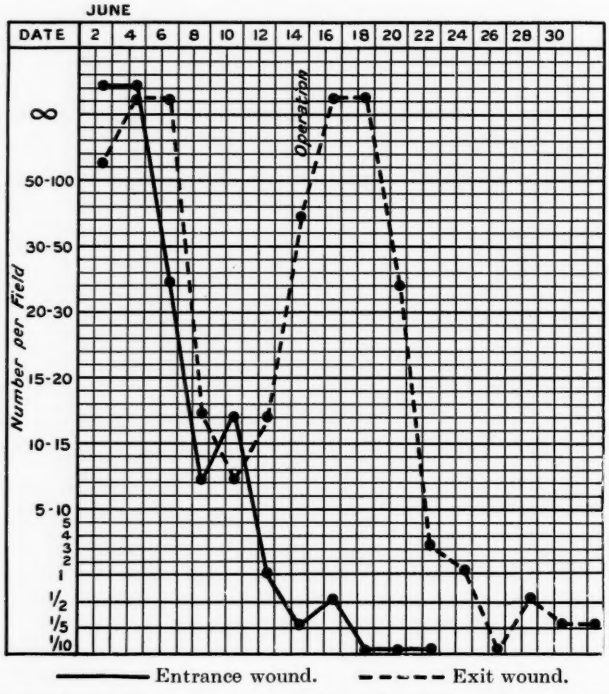

FIG. 362.—Bacterial chart from a case of through-and-through wound of the thigh. A piece of clothing was removed from the exit wound on June 14.

that we bring forward these notes. The gradual recognition of the importance of contamination and reinfection of infected wounds has led to the development of aseptic principles as applied to their treatment; and it seems that much the same evolution of thought is taking place to-day in regard to infected war wounds, as took place in the past in regard to general operative surgery.

A proper insistence on the essential importance of such aseptic principles we owe to Dr. Alexis Carrel, as well as the technique of the irrigation method bearing his name which has proved so valuable in the treatment of war wounds. Although in many ways unable to agree with his interpretation of the mode of action of hypochlorite solution, we wish to express our gratitude to him for his great courtesy and help during a visit to his hospital at Compiègne, and our admiration of the valuable work carried out there by himself and his co-workers.

Much of the work recorded in this paper could not have been carried out without the help and co-operation of Dr. C. Dean, who has been responsible for the medical and bacteriological work at this hospital. He has employed the principles discussed in this paper in a large number of chest wounds, and the results which he has obtained are appearing in the *Quarterly Journal of Medicine*.

We further wish to express our thanks to Millicent, Duchess of Sutherland, for the enthusiastic and understanding manner in which she has helped us to carry out this treatment, and to the nursing staff of this hospital, whose interest and co-operation in the work have been invaluable. Mr. H. A. Douglass, A.R.I.B.A., we have to thank for his able assistance in the design and construction of splints, Miss E. McNeill for her careful compilation of records, and Private J. Gowans, R.A.M.C., for much valuable help in the laboratory work.

It has seemed to us desirable in the following Appendix, which gives an abstract of a certain number of cases treated on the above lines, only to record such as have been kept under treatment here until all reasonable probability of the usual complications occurring has passed. While by such a selection, naturally, all the failures are presented, yet it seems to us more satisfactory than to publish a larger number of cases the ultimate outcome of which is unknown, in order to show more favourable statistics. The appended cases (pp. 449–461) are brought up to date to August 15, 1917.

APPENDIX.

A. SUMMARY OF MUSCLE WOUNDS:

A Statistical Summary of 48 *Cases, selected chiefly for their large surface area, or involvement of important muscles.*

13 cases had an initial infinity count, the rest being of varying lower septicity.

Average time to disappearance of visible dead tissue, was just over 9 days.

7 of the 48 cases were still incompletely sterile on transfer.

10 cases were sutured with perfect success.

4 cases were sutured with partial success.

In 2 of the partial failures the skin could not be approximated.

27 cases were sterile on transfer.

B.—TABLE OF CASES.

T. No.	Days after wound when admitted	G = Gunshot wound S = Shell wound	Temperature °F	Sepsis; No. of bacteria per microscopic field	Wound, Complications, etc.	Disappearance of visible dead tissue, in days	Days taken to obtain sterility	Days under treatment	Condition on transfer
2502	4	G	100	2	Compound fracture of *femur*. Foreign body removed here. Wound sterilized and sewn up. Bone plated 28th day after suture	7	20	71	Primary union
2451	12	G	102	15–20	Compound comminuted fracture of *femur* ..	20	38	48	Union. No sinus
2450	12	S	100	5	Compound fracture of external condyle of *femur*	18	26	35	Wound healthy. No sinus
2440	7	S	101	∞	Transverse fracture of *femur* just below trochanter	10	14	63	No sinus to bone
2412	5	G	101	50–100	Compound comminuted fracture of lower third of *femur*. Secondary abscess	13	Incomplete	71	Sinus to ? sequestrum
OT44	9	S	102	5–10	Compound comminuted fracture of lower third of *femur*	19	Incomplete	51	No sinus. No sequestra
2983	7	S	99·5	∞	Large wound. Compound fracture of internal condyle of *femur*	9	15	18	Superficial granulating surface
2902	7	S	101	20–30	Perforating wound. Oblique fracture of *femur*	9	11	34	Small sinus present, which has been sterile for 20 days
2741	7	S	100	50–100	Large anterior wound of thigh. Much laceration of muscles. Comminution of middle third of shaft of *femur*	30	49	69	Definite union. Sinus still present
2833	11	S	101	∞	Perforating wound of lower third of thigh. Comminution of *femur*	21	30	52	Wounds clean. Small sinus
3133	3	S	103	∞	Lacerating wound, exposing about five inches of comminuted *femur*	25	Incomplete	—	Still under treatment
3182	4	S	101	∞	Compound fracture of *femur*	25	Incomplete	—	Still under treatment
2756	11	G	102	15–20	Compound comminuted fracture of *femur*. Two secondary abscesses during convalescence. Union firm in 2½ months	—	—	—	—
2958	3	S	104	∞	Compound comminuted fracture of *femur*	30	60	—	Wound only about one inch across. No sinus.

2756	11	G	102	15–20	Compound comminuted fracture of *femur*. Two secondary abscesses during convalescence. Union firm in 2½ months	—	—	—	—
2958	3	S	104	∞	Compound comminuted fracture of *femur* Malignant œdema. Longitudinal and transverse incisions of thigh muscles	30	60	—	Wound only about one inch across. No sinus. Firm union. Still under treatment
2761	3	G	101·5	—	Small anterior, large posterior wounds. Compound fracture of middle third of *femur*	28	—	60	Wounds superficial. No sinus
2890	5	G	101	2	Perforating wound of middle third of right thigh, large external opening. Long oblique fracture of *femur*	9	13	54	External wound sewn up 38th day, partial success
3125	12	S	100	∞	Compound fracture of lower end of *femur*, implicating *knee-joint*	15	24	—	Still under treatment
2822	3	G	101	∞	Perforating wound of left thigh, involving *suprapatellar pouch*	13	19	43	Wounds superficial
2498	7	G	100	30–50	Through-and-through wound on posterior aspect of *knee-joint*	4	11	22	Primary union after suture
2447	12	G	101·8	30–50	*Patella* exposed. Laceration of extensor muscles. *Joint* exposed. Counter-incisions into main joint-cavity and suprapatellar pouch	38	50	80	Small sinus. Wounds healthy
2634	2	S	101·2	½	Compound comminuted fracture of *patella* ..	7	17	19	Wound almost closed. Anterior joint-cavity alone involved
2450	12	G	100	5	Penetrating wound of *knee-joint* with fracture of external condyle of *femur*	18	Incomplete	25	Sinus still present. Wound healthy
2627	9	G	101·4	2	Large wound of popliteal space, involving *knee-joint*	2	12	20	Wound sutured. Primary union
2585	8	S	101·4	5	Compound comminuted fracture of *patella* ..	9	12	17	No sinus. Wound superficial and clean. Anterior joint-cavity alone involved
2865	2	S	100·2	∞	Wound of *suprapatellar pouch*	16	21	25	Wound quite clean
2780	5	G	103	15–20	Wound of *knee-joint* partially sutured at C.C.S. Pus evacuated from anterior part of joint here	30	60	90	Knee still swollen. No discharging sinuses
2912	9	S	102	∞	Wound of right *knee-joint*. Joint opened, patella wired, and joint closed at C.C.S. Re-opened for acute sepsis on admission here	60	75	77	Wounds clean. No sinus

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TABLE OF CASES—*continued.*

T. No.	Days after wound when admitted	G = Gunshot wound S = Shell wound	Temperature °F	Sepsis: No. of bacteria per microscopic field	Wound, Complications, etc.	Disappearance of visible dead tissue, in days	Days taken to obtain sterility	Days under treatment	Condition on transfer
2757	4	G	101	∞	Tunnel track through upper end of *tibia*, involving *knee-joint*	17	22	100	Wounds completely healed over
OT49	14	S	102	20–30	Wound of left *knee-joint*, sewn up at C.C.S. Re-opened for pus here. Compound fracture of head of *tibia* found at operation. Several times during convalescence it was thought leg would have to be amputated	45	58	79	Wounds superficial. No sinus
2829	4	S	102	15–20	Left *knee-joint* washed out and closed at C.C.S. Stitches removed here, with escape of large quantity of pus	16	23	74	Wounds superficial and granulating. No sinus
2877	23	S	—	20–30	Wound of right *knee-joint*, closed at C.C.S. Considerable œdema on admission here. Joint re-opened. Quantity of pus evacuated	15	22	60	Wound superficial. One shallow sinus
2549	5	G	103	∞	Perforating wound, with fracture of upper end of *tibia* into *knee-joint*. Multiple other wounds. Secondary hæmorrhage of right arm, which made patient so ill that amputation of leg became necessary. Blood transfusion at operation	—	—	—	Amputation 1 month 26 days after admission. Died 12 days later
2851	5	S	100	∞	Compound fracture of head of *tibia* involving *knee-joint*. Post-crucial infection	—	—	32	General condition grave and getting worse. Amputation lower third of thigh. Recovery
2534	3	S	100·8	∞	Compound comminuted fracture of *tibia* and *fibula*. Gap of 2 in. in tibia. Much destruction of muscle	30	49	58	Wound clean. Shallow sinus still present
2654	3	S	99·8	Slight	Perforation of *tibia*, with cracks radiating ..	2	Incomplete	5	Wound cleaning. Sinus still present
2729	6	S	100·4	20–30	Compound comminuted fracture of lower third of *tibia*	22	Incomplete	24	Wound almost sterile. Sinus still present
2578	12	G	99·2	5–10	Compound fracture of *tibia* and *fibula* ..	10	20	30	Wound clean. Very small sinus to site of

					still present				
2729	6	S	100·4	20–30	Compound comminuted fracture of lower third of *tibia*	22	Incomplete	24	Wound almost sterile. Sinus still present
2578	12	G	99·2	5–10	Compound fracture of *tibia* and *fibula* ..	10	20	30	Wound clean. Very small sinus to site of fracture
2553	6	S	100	2	Compound fracture at junction of upper and middle third of *tibia*	2	9	19	Wound sterile. Sinus to site of fracture. Wound healthy on admission
2547	14	S	100·8	20–30	Compound comminuted fracture of lower third of *tibia*	10	18	30	Wound clean. Sinus to bone
2525	6	G	99	5–10	Bullet has splintered *tibia*, but there is no actual discontinuity	5	8	21	Wound sterile. Small sinus to cavity
2467	6	S	102·6	∞	Compound oblique fracture of *tibia*	20	46	60	Union. Wound nearly closed. No sinus
2443	5	S	100·8	∞	Compound comminuted fracture of lower third of *tibia*. Bone exposed in wound. Sequestra removed	20	50	63	Wounds clean. Some union. Sinus to fracture
2785	2	S	102·4	50–100	Incomplete fracture of *tibia*. Much comminution, but medial border not destroyed	10	Incomplete	41	Surface wounds clean and granulating. Sinus still present
2975	4	S	102·2	∞	Compound comminuted fracture of lower end of *tibia*, very oblique. After 60 days wound clean and sterile. Position bad. Six-holed plate applied. Wound left open. Carrel tubes inserted. Bacterial curve went up to 30–50. Sterile again in 18 days	30	50	—	Still under treatment. Plate covered. No sinus. Plate removed later, wound healed
3052	5	S	—	—	Oblique fracture of *tibia*	11	20	—	Union. No sinus. Wound still under treatment
2967	3	S	101	20–30	Compound comminuted fracture of *tibia*. Perforating wound	13	50	—	Wound sterile. Firm union
2906	3	S	100	∞	Perforating wound of lower part of leg. Compound fracture of *tibia*. Secondary hæmorrhage from posterior tibial artery 7th day after admission. Sequestra removed on 34th day	40	Incomplete	56	—
2977	4	S	104	5–10	Perforating wound. Badly comminuted fracture of middle of *tibia*	10	15	47	Union commencing. Wounds clean

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TABLE OF CASES—*continued.*

T. No.	Days after wound when admitted	G = Gunshot wound S = Shell wound	Temperature °F	Sepsis: No. of bacteria per microscopic field	Wound, Complications, etc.	Disappearance of visible dead tissue, in days	Days taken to obtain sterility	Days under treatment	Condition on transfer
2791	3	S	103	∞	Comminution of *tibia* and *fibula* 2 in. above ankle-joint. Much loss of substance	30	Incomplete	52	Alinement good. Large gap still present. Numerous sequestra continually coming away
2827	2	S	101	20–30	Excavation of head of *tibia*	30	46	102	Wound clean and superficial. No sinus
3037	5	S	—	∞	Compound comminuted fracture of middle third of *tibia*	14	18	33	Wounds clean
2866	4	S	102	∞	Large lacerated wound of lower third of leg. Compound fracture of *tibia*	43	Incomplete	72	No union. Several sequestra still present
2868	5	S	102	∞	Compound fracture of middle third of *tibia*. Lacerated wound on anterior aspect of leg. Several secondary abscesses	60	Incomplete	72	Some union. Sequestra still present
2757	4	G	101	20–30	Tunnel track through upper end of *tibia*, implicating *knee-joint*	60	75	100	Wound closing
OT73	1	G	102	∞	Perforating wound. Compound fracture of *tibia* and *fibula*	14	30	44	Union. Small sinus
OT56	2	S	100	∞	Large, intensely foul wound on anterior aspect of leg. Large excavation in head of *tibia*. Tetanus bacilli present	45	Incomplete	87	Excavation filled with granulation tissue. Wound closing
2950	3	S	102	∞	Wound on outer side of leg. Foreign body removed from head of *tibia*	8	13	30	Wound superficial. No sinus
2776	2	S	101	∞	Extensive wound on inner aspect of leg. Much destruction of middle third of *tibia*	20	38	70	Wound clean & closing. Sinus present. Infection by *B. pyocyaneus* delayed sterilization
2837	2	S	101	∞	Lacerated wound on anterior aspect of leg. Compound fracture of middle third of *tibia*	30	Incomplete	52	Union, but some necrosis.
2743	3	S	103·8	5–10	Compound fracture of *fibula*	5	8	14	Wounds clean
2522	3	G	98·8	∞	Compound comminuted fracture of head of *fibula*	6	17	32	Wounds quite clean. No sinus

2837	2	S	101	∞	Lacerated wound on anterior aspect of leg. Compound fracture of middle third of *tibia*	30	Incomplete	52	Union, but some necrosis.
2743	3	S	103·8	5–10	Compound fracture of *fibula*	5	8	14	Wounds clean
2522	3	G	98·8	∞	Compound comminuted fracture of head of *fibula*	6	17	32	Wounds quite clean. No sinus
2473	4	G	99·6	∞	Compound comminuted fracture of *fibula*. Large gap in bone	3	22	46	Wound quite clean. No sinus
2606	6	G	99·6	5–10	Large wound of outer side of leg. Compound fracture of *fibula*. Much loss of substance	12	30	65	Wound sterile and closing rapidly. No sinus
2688	12	G	99·4	∞	Multiple wounds of outer side of leg Compound fracture of *fibula*	23	34	56	Wounds sterile and closing rapidly. No sinus
2963	4	S	99	—	Compound fracture of lower end of *fibula* ..	5	8	12	Wounds superficial
3015	3	S	100	∞	Compound comminuted fracture of head of *fibula*	11	Incomplete	12	Sepsis still present
3018	3	S	99	½	Compound fracture of *fibula*, middle third ..	—	—	19	Wound quite superficial
2951	2	S	101·5	∞	Large lacerated wound. Compound comminuted fracture of *fibula*	9	18	34	Wound quite superficial. No sinus
2514	5	S	101·5	∞	Fracture of external malleolus and lower end of *tibia* into joint surface	11	25	36	No sinus
2516	9	S	103	∞	Compound comminuted fracture of *tibia* and *astragalus*. Spread of infection up tendon sheaths	—	—	—	Amputation 19 days after admission
2703	5	G	101	5–10	Compound comminuted fracture of external malleolus and articular surface of *tibia*. Some loose fragments removed	19	39	83	Wound superficial. Some swelling still present
2888	3	S	103	∞	Fracture of lower end of *tibia*. *Ankle-joint* involved and *astragalus* fractured. Two secondary hæmorrhages. Leg amputated [*Six cases of ankle-joint injuries, complicated by severe tarsal fractures, in which amputation was performed shortly after admission, are not given in detail, as no attempt at conservation was felt to be justified.*]	—	—	39	Some sloughing of flaps
2711	4	G	99·4	1	Compound fracture of *scapula*. Muscles involved	4	9	13	Wound clean and sterile Sinus still present
2690	5	G	99·4	10–20	Compound fracture of vertical border of *scapula*	7	11	14	Wound sterile. Small sinus to site of fracture

Continued on next page.

TABLE OF CASES—*continued.*

T. No.	Days after wound when admitted	G = Gunshot wound S = Shell wound	Temperature °F	Sepsis: No. of bacteria per microscopic field	Wound, Complications, etc.	Disappearance of visible dead tissue, in days	Days taken to obtain sterility	Days under treatment	Condition on transfer
2433	4	G	—	30–50	Compound comminuted fracture of *scapula*. Foreign bodies and loose bone removed. Wound closed by means of clips and sutures	5	11	28	Wound healed, scar soft and supple. Sutured on 15th day
2573	5	G	101	4	Compound fracture of *scapula*. Much comminution. Loose fragments removed	13	28	37	Wound sterile. No sinus
2957	4	S	101	15–20	Dirty through-and-through wound of shoulder. Compound fracture of *scapula*	7	10	13	Entrance wound closed. Exit wound superficial. No sinus
2565	10	S	103·4	—	Foreign body removed from venter of *scapula*, which was fractured. Destruction of glenoid fossa. Humerus subluxated	—	Incomplete	45	Wounds healthy. No sinus
3046	5	S	101	20–30	Compound fracture of *acromion process*, not involving shoulder-joint. Some loose bone and cloth removed on admission	11	16	18	Wounds sterile
2831	3	G	102	30–50	Compound comminuted fracture of shaft of *humerus*. Considerable loss of substance	37	Incomplete	53	Wounds clean. No bone exposed
2587	6	S	100·5	5–10	Compound comminuted fracture of *humerus* ..	15	20	32	Union. No sinus
3054	4	S	99	∞	Compound comminuted fracture of *humerus* ..	22	30	54	Firm union. No sinus
OT59	4	S	103	∞	Very comminuted fracture of upper third of *humerus*. Several sequestra removed	—	75	90	Firm union. Small sinus
3053	5	S	101·5	—	Compound fracture of *humerus*	17	24	27	Firm union. No sinus
					,, ,, ,, *clavicle*	5	17	27	Wound healed
2956	4	S	102	30–50	Compound fracture of *humerus*, badly comminuted	25	36	92	Union. No sinus
3182	4	S	101	∞	Compound fracture of *humerus*	25	Incomplete	—	Still under treatment
3011	3	S	100	20–30	Compound comminuted fracture of upper third of *humerus*	20	29	34	Union fairly firm. No sinus
2924	3	S	102	∞	Large wound of anterior aspect of upper arm. Compound fracture of *humerus*	30	37	68	Firm union. No sinus

3182	4	S	101	∞	Compound fracture of *humerus*	25	Incomplete	—	Still under treatment
3011	3	S	100	20–30	Compound comminuted fracture of upper third of *humerus*	20	29	34	Union fairly firm. No sinus
[illegible]	3	S	102	∞	Large wound of anterior aspect of upper arm. Compound fracture of *humerus*	30	37	68	Firm union. No sinus
2839	2	G	101	30–50	Compound fracture of upper end of *humerus*. Foreign body removed on admission	14	40	73	Firm union. No sinus
2935	3	S	99	1	Compound fracture of lower end of *humerus*. Bone fractured in two places	11	12	20	Wounds sterile and quite small
2950	3	S	102	∞	Compound comminuted fracture of lower third of *humerus*	14	19	30	Wound quite superficial. Firm union
2695	15	S	100	5–10	Compound comminuted fracture of *humerus* ..	7	Incomplete	14	Wounds progressing. Sinus still present
2745	3	G	102	10–15	Compound fracture of *humerus*	5	Incomplete	21	Wounds healthy. Fracture in good position. Sinus still present
2622	6	S	101	10–20	Compound comminuted fracture of *humerus* middle third	5	Incomplete	9	Wound healthy. Sinus to bone
2587	6	G	100·2	5–10	Compound comminuted fracture of *humerus*, communicating with joint	6	18	32	Union. No sinus
2569	6	S	100·2	2	Compound fracture of internal condyle of *humerus*	11	Incomplete	23	Wound healthy. Sinus still present
2554	4	G	99	2	Compound comminuted fracture of lower third of *humerus*	15	20	32	Union. No sinus
2821	3	G	102	30–50	Large wound on outer side of upper arm. Compound comminuted fracture of *humerus*. Much loss of substance	25	32	53	Wound superficial. No sinus. Slight union
2763	3	S	100	—	Compound comminuted fracture of upper end of *humerus*. Ulnar paralysis. Severe secondary hæmorrhage 16th day after admission. Large abscess developed in axilla 26th day. Extensive necrosis of upper fragment. Amputation through shoulder-joint. Death	—	—	28	—
2844	4	S	100	∞	Compound fracture of lower third of *humerus*. Foreign body removed	20	30	42	Wounds quite superficial. Good callus formation. Union
2899	4	S	101	∞	Large wound on posterior aspect of middle third of arm. Compound comminuted fracture of *humerus*	10	13	30	Wound closing rapidly, dry, clean, and superficial

Continued on next page.

TABLE OF CASES *continued.*

T. No.	Days after wound when admitted	G = Gunshot wound S = Shell wound	Temperature °F	Sepsis: No. of bacteria per microscopic field	Wound, Complications, etc.	Disappearance of visible dead tissue, in days	Days taken to obtain sterility	Days under treatment	Condition on transfer
2801	6	S	103	∞	Large muscle wounds of upper arm. Extremely comminuted fracture of *humerus*. Also left-sided hæmothorax	14	Incomplete	57	Wounds clean. Small sinus. ? sequestrum. Fairly firm union
2679	5	S	102	20–30	Extensive lacerated wounds of upper arm. Considerable destruction of all heads of triceps. Musculospiral nerve exposed. Compound fracture of *humerus*	14	Incomplete	86	Wounds closing. Persistent sinus. Some sequestra present
2992	2	S	100	20–30	Perforating wound. Partial fracture of lower third of *humerus*	10	22	26	Wound superficial and sterile
2721	4	S	99·6	20–30	Compound fracture of *humerus* just above olecranon fossa	10	13	46	Union firm. No sinus to fracture
2641	2	G	103	∞	Compound fracture of lower end of *humerus*, involving elbow-joint	30	63	96	Small sinus. Slight union
2546	11	S	104	30–50	Wound on anterior aspect of arm, 3 × 4 in., communicating with wound on upper part of forearm, 7 × 4 in. Comminution of lower end of *humerus*, involving *elbow-joint*	75	82	86	Some flexion possible at elbow
2789	2	S	103	∞	Wound of *elbow-joint*. Comminution of *ulna* and lower end of *humerus*. Several secondary abscesses. General condition at one time serious	60	90	104	Wound superficial and clean. Some movement
2954	32	S	101	2	Wound penetrating right *elbow-joint*. No bony injury	7	10	14	Wound clean, sterile. Small sinus
2466	6	G	100·8	5	Compound fracture of *ulna* at elbow and wrist. *Wrist-joint* and *elbow-joint* involved	46	60	81	Wounds clean, sterile. No sinus
2598	4	S	100	∞	Compound comminuted fracture of upper end of *ulna*	40	Incomplete	57	Elbow still slightly swollen. Wound nearly healed
3041	4	S	102	∞	Multiple wounds. Large wound on dorsum of forearm. Compound fracture of *ulna* and *radius*. Very septic	14	30	33	Wound clean and small
2509	4	S	102	∞	Compound comminuted fracture of *ulna* and *radius*. Extensor muscles lacerated. Ten-	11	25	40	Wound clean and closing rapidly. Sinus

					ly healed				
3041	4	S	102	∞	Multiple wounds. Large wound on dorsum of forearm. Compound fracture of *ulna* and *radius*. Very septic	14	30	33	Wound clean and small
2509	4	S	102	∞	Compound comminuted fracture of *ulna* and *radius*. Extensor muscles lacerated. Tendons exposed	11	25	40	Wound clean and closing in rapidly. Sinus to bone
2576	5	G	102	15–20	Compound comminuted fracture of *ulna* ..	5	19	30	Wound healthy. Granulating surface. No sinus
2680	5	G	100	20–30	Compound comminuted fracture of *ulna* ..	5	8	9	Wound clean. Sinus to bone
2622	6	S	99·4	3	Compound fracture of *ulna* and *radius* ..	3	6	9	Wound covered with clean granulations
2591	4	S	99·8	5–10	Compound comminuted fracture of middle third of *ulna*	5	7	10	Wound healthy. Small sinus to bone. Letter received saying wound completely healed 27 days after evacuation
2501	5	S	100·8	∞	Compound fracture of lower end of *ulna*. Nerve divided. Loss of substance	15	37	40	Wound clean and ready for suture. No sinus
2691	7	S	100·6	20–30	Extensive wound on extensor and flexor aspects at junction of middle and lower thirds of right forearm. Compound fracture of *ulna* and *radius*	16	34	41	Wound clean and granulating
2636	2	S	101·2	∞	Compound comminuted fracture of *radius*. Pieces of loose bone removed	7	37	40	Wound healthy. Sinus to bone
2716	8	S	100	5	Oblique fracture of middle third of *radius* ..	7	Incomplete	13	Wound almost sterile. Sinus to bone
2570	6	S	99·6	20–30	Compound fracture of *radius* just below neck. Much laceration of muscles	8	10	15	Wound clean. Small sinus to fracture
2518	7	S	101	30–50	Multiple perforating wounds. Compound fracture of middle of *radius*	12	14	40	Wounds sutured. Primary union
2509	4	S	102	∞	Comminuted fracture of *radius* below neck. Compound fracture of *ulna*. Extensor muscles lacerated, tendons exposed	11	25	40	Wound clean and closing in rapidly. Sinus to fracture
2411	5	S	101	∞	Compound comminuted fracture of lower third of *radius*. Much loss of substance	15	42	65	Wound clean and granulating. No sinus
2731	5	S	99·4	5–10	Compound comminuted fracture of middle third of *ulna*	4	Incomplete	10	Wound almost sterile. Sinus to fracture

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TABLE OF CASES—*continued.*

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2600	3	S	102	4	Large wound involving whole *carpus* and part of *metacarpus*	37	52	92	Wound superficial. No sinus
3017	18	S	100	5–10	Multiple wounds. Compound fracture of external *carpal* bones	10	18	26	Wound small. Granulations. Bones covered over
2518	7	S	101	∞ tetanus	Large wound involving whole of *radiocarpal joint*. Bones shattered	8	60	40	Wound superficial and sterile
2466		G	100·8	5–10	*Ulna* exposed and fractured. Pieces of *carpal* bones removed	15	52	81	Wound clean and sterile. No sinus
2635	3		100·8	∞	Comminution of *metacarpals* and *carpus*, with involvement of *wrist-joint*	23	34	54	Wound closed. No communication with joint
2903	5	S	102	∞	Extensive wound of inner aspect of wrist and forearm. Fracture of lower end of *ulna* and *carpus*	37	Incomplete	56	Wounds granulating. Small sinus
2840	2	G	100	∞	Compound fracture of lower end of *ulna* and of *carpus*. Some loose fragments removed on admission	30	44	65	Exit wound closed. Entrance wound superficial. No sinus
2503	5	S	102·8	½	Compound fracture of *phalanx* of second finger	10	12	40	Wound closed. No sinus
2589	8	G	103·4	3	Multiple wounds of right hand. Index finger absent. Palm lacerated. Compound fracture of *metacarpal*	6	Incomplete	11	Wounds healthy. Sinus present
2474	4	G	101·6	∞	Outer four *metatarsals* exposed and fractured. Amputation of foot 30 days after admission. Complete disorganization of tendons and muscles	—	—	—	Stump clean. Healing well
2451	12	G	100·4	∞	Fracture of 4th and 5th *metatarsals*	25	Incomplete	48	Wound healthy. Sinus to bone
2427	3	G	100·4	∞	Laceration of muscles, all *phalanges* of hallux removed	15	40	59	Sewn up
2670	3	S	103	—	Lacerated wound of foot. Compound fracture of the 3 outer *metatarsals*. Several abscesses	28	38	51	Wounds clean and superficial

2427	3	G	100·4	∞	Laceration of muscles, all *phalanges* of hallux removed	15	40	59	Sewn up
2670	3	S	103	—	Lacerated wound of foot. Compound fracture of the 3 outer *metatarsals*. Several abscesses developed during treatment	28	38	51	Wounds clean and superficial
2511	8	S	105	15–20	Compound fracture of middle *phalanx* of second toe	19	34	40	Wound closed. No sinus
2427	3	G	100·4	∞	Large wound removing big toe, all *phalanges* of hallux removed, part of *metatarsal* exposed. Exposed metatarsal removed	35	41	59	Wound sutured. Sutures removed
2971	4	S	100	10–15	Compound comminuted fracture of *os calcis*. Some loose bone removed	13	17	26	Wound quite lean and dry. No sinus
2740	3	S	103	10–15	Compound fracture of *sacrum*	10	18	24	Wounds clean. Small sinus
3008	3	S	99	5	Wound of right buttock. Compound fracture of *ilium*. Foreign body removed from pelvis	6	11	13	Wound quite dry and sterile
2453	6	G	99	2	Compound fracture of crest of *ilium* and of spinous processes of *lumbar vertebræ*	10	15	52	Sutured 30th day after admission
2775	3	S	102·4	∞	Large wound, inclined to bleed, passing down to *ilium*. Foreign body removed. Two secondary hæmorrhages from gluteal artery. Internal iliac tied. Dakin solution discontinued	26	Incomplete	42	Buttock wound almost sterile and very healthy
2737	4	G	102	10–15	Large wound of left buttock, involving anus and external sphincter. Colostomy performed	11	Incomplete	35	Wound clean
2864	4	S	101·4	∞	Large wound, 3 × 2 in., on right side of vertebral column at level of sacro-iliac joint. Bone exposed	10	Incomplete	25	Wound cleaning slowly. General condition good
2791	4	G	102·4	2	Entrance wound on inner aspect of thigh. Exit through buttock	5	10	12	Wound clean and sterile
2771	7	S	101·6	∞	Wound passing down to and through *ilium*. Foreign body not found	4	Incomplete	7	Wound healthy. Sinus to bone
2446	5	S	99·6	30–50	Wound of buttock, 3 in. deep, leading to posterior aspect of *ilium*	33	36	38	Wound clean. Deep sinus still present
2428	5	G	—	5	Small buttock wound, with sinus about 2 in.	4	8	28	Wound sewn up. Primary union 11th day
2432	6	G	—	20–30	Wound of left buttock	4	7	12	Wound closing
OT50	6	S	103·2	30–50	Entrance wound in left buttock. Metal fragment removed at C.C.S.	10	Incomplete	11	Wound much cleaner

GUNSHOT WOUNDS OF THE KNEE-JOINT: A REPORT ON 100 CONSECUTIVE CASES.

By Captain E. TISSINGTON TATLOW, R.A.M.C. (T.)

During the past twelve months, the treatment of gunshot wounds of the knee-joint at the clearing stations has improved very considerably, thus simplifying the problems presented to the surgeon at the base hospital. This improvement must be attributed largely to earlier operation, complete removal of damaged and infected tissue, and in consequence the ability to close the wounded joint completely. At one time it was a rare event to see a case of a grossly injured knee-joint admitted at the base completely sutured; of recent months this is almost the rule.

STATISTICAL SUMMARY.

The cases in this series have been under my treatment at a base hospital this year. Of the 100 cases, 2 died, both after amputation; 4 were successfully amputated; 9 were successfully resected; and 12 were unoperated upon. The remaining 73 were evacuated to England, after operation either at the base or at the clearing station, with a normal temperature, and either healed or granulating wounds, or at most a small discharging sinus.

Varieties of Lesion.—The lesions of the knee-joint may be grouped under five headings, referred to in detail below, as follows:—

Tear of the capsule only	9 cases
Through-and-through wound without bone injury	13 ,,
Through-and-through wound with bone injury	25 ,,
Retained foreign body in the joint without bone injury	24 ,,
Retained foreign body with bone injury	29 ,,

Missile.—With regard to the nature of the projectile, the figures are as follows:—

Revolver bullet	1 case
Machine-gun bullets	4 cases
Rifle bullets	9 ,,
Shrapnel balls	9 ,,
High-explosive fragments	77 ,,

The term 'high-explosive fragment' is used to include fragments of shell, bombs, and grenades.

Organisms.—Cultures of the fluid of the joint were made in 37 cases, with the following results:—

No organisms grown	17 cases
Streptococci	13 ,,
B. perfringens	3 ,,
Staphylococcus aureus	2 ,,
Staphylococcus albus	1 case
Diphtheroid (? contamination)	1 ,,

It is of interest to consider the results of the 13 cases found to have a general streptococcal infection of the joint: 5 were resected; 5 were amputated; 2 had resections of the patella; 1 had Carrel-Dakin treatment and drainage. In the total series, only 11 cases were resected and 6 amputated, so the streptococcal infection may be seen to account for a large proportion of these.

Of the 3 cases infected by the *B. perfringens*, in 2 the joint was resected; in 1 a high-explosive fragment was removed, followed by B.I.P.P. treatment and suture. One case which was resected had, in addition to the *B. perfringens* infection, a severe fracture of the intercondylar notch, in which a large high-explosive fragment was imbedded.

Tear of the Capsule only.—9 cases.

Amputation	2
Resection	1
B.I.P.P. and suture ..	5
Salt pack	1

The two amputations and the resection were not diagnosed as being penetrating wounds of the knee-joint for some days after their being wounded. All the three were infected by the streptococcus.

Through-and-through Wound without Bone Lesion.—13 cases.

No operative treatment	9
Excision of wounds and suture ..	4

Foreign Body in the Joint and no Bone Lesion.—24 cases.

Removal of the missile, B.I.P.P., and suture ..	6
Removal of the missile, lavage, and suture ..	6
Carrel-Dakin treatment	2
Formalin and glycerin injections	2
No operative treatment for removal	7
Salt pack	1

Bone Lesion involving the Knee-joint.—54 cases.

Compound fracture of the patella	11
Fracture of the shaft of the femur	5
Fracture of both condyles	3
Fracture of a single condyle	20
Fracture of the head of the tibia	10
Fracture of the internal condyle and the outer head of the tibia ..	1
Fracture of the patella, external condyle, and outer head of the tibia	1
Fracture of the patella and the inner head of the tibia ..	1
Fracture of the patella and both condyles	1
Fracture of the patella and the intercondylar notch	1

Wounds of the Joint involving the Patella.—11 cases.

Resection of the patella	4
Suture of the patella fragments	1
Cases treated conservatively after toilet, foreign body removal, and suture of capsule	6

The four cases of the resection of the patella are reported to be walking, with stiff knee-joints. The case of patella suture resulted in ultimate necrosis of the patella, with a stiff knee.

Wounds of the Joint involving the Shaft of the Femur.—5 cases.

One had a rifle bullet in the shaft.

A final report has only been received concerning two of these cases. Both have mobile knee-joints.

Wounds of the Joint involving Both Condyles.—3 cases.

Treated conservatively	..	1
Resection of the joint	..	2

Both resections had bony union on evacuation. One was performed for fracture of the condyles and intercondylar notch, with *B. perfringens* infection; the other was a primary resection for severe comminution of both condyles, performed at the clearing station seven hours after the time of wounding.

Wounds of the Joint involving One Condyle.—20 cases.

a. External condyle.—7 cases (slight bone injury 4; severe 3).

Treated conservatively	..	4
Amputation ..	..	1
Resection of the joint	..	2

Two were evacuated with minute foreign bodies remaining in the condyle.

b. Internal condyle.—13 cases (slight bone injury 4; severe 9).

The entire series were treated conservatively. One was evacuated with a shrapnel ball remaining in the condyle, and one with multiple high-explosive fragments in the joint.

Wounds of the Joint involving the Head of the Tibia.—10 cases (severe bone injury 3; slight 7).

Amputation ..	..	1 (died)
Joint resection ..	..	2
Treated conservatively	..	7

Wounds of the Joint involving Several Bones.—5 cases.

Two of these were amputated: one a case of fracture of the patella, the external condyle, and the outer head of the tibia (in this case osteomyelitis of the shaft of the femur developed); the other a case of fracture of the patella and both condyles (here an acute streptococcal arthritis was present). Two other cases are reported to have a fair degree of mobility and to be good functional results: one a case with a severe fracture of the internal condyle and of the outer head of the tibia; the other a case of a fracture of the patella and the head of the tibia. The fifth case, a fracture of the patella and the intercondylar notch, is still in the hospital; the patella was resected at the casualty clearing station, and the bone cavity treated with B.I.P.P.

Thus, of the 54 cases with a bone lesion, 1 died after amputation, 4 were successfully amputated, and 7 had resections performed; all the resections have been evacuated to England with good union, and 3 are reported to be walking well. Of the other 42 cases evacuated on their splints, 13 reports have been received: 7 cases have stiff, useful knee-joints (4 of these were cases of resected patella, 1 a case of fractured patella which was sutured and subsequently necrosed, 1 was a case of a fractured condyle); 7 cases

are reported to have mobile knee-joints (2 were fractures of the shaft of the femur, 1 was a fracture of the patella and head of the tibia, 1 was a fracture of the internal condyle and the head of the tibia, 2 were fractures of the internal condyle, and 1 was a fracture of the head of the tibia only).

Of the 100 cases, 12 did not undergo any operation. Of these, 10 were cases with through-and-through wounds (3 of these had fractures of the shaft of the femur, 1 had a fracture of the head of the tibia, and 1 a fracture of the condyle); 2 of the cases had retained foreign bodies (one, a shrapnel ball in the internal condyle; the other, multiple minute high-explosive fragments in the joint). In 6 the wounds were caused by rifle bullets, in 3 by shell fragments, in 2 by machine-gun bullets, and in 1 by a shrapnel ball.

In the series, 68 cases were operated upon at the clearing stations. Of these, 35 were completely closed; these cases required no further operative treatment, with two exceptions—in one case a revolver bullet was left in, and had to be removed; in another, a general infection of the joint with the *Staphylococcus aureus* supervened, necessitating opening up.

Of the 34 cases operated on at the base, 14 had had a previous operation at the clearing station; 20 had had no operative treatment. Of the 20 cases unoperated upon at the clearing station, 3 were amputated, 5 resected, 2 had resections of the patella, 6 had operations for the removal of foreign bodies, 1 had wound enlargement, 1 had a tear in the capsule excised and sutured, 1 had an exploratory operation, and 1 was treated by repeated aspirations. Of the 14 cases which had been previously operated upon, 2 had foreign bodies removed which the casualty clearing station had failed to find, 3 were amputated, 4 had open wounds which had to be enlarged, 1 had an abscess evacuated outside the joint, 1 had a sutured joint opened up, and 3 were resected.

That is to say, the clearing stations sent down 100 cases of gunshot wound of the knee-joint; 68 had been operated upon there—of these, 14 required re-operation; 32 were unoperated upon—of these, 20 required operation.

TREATMENT.

I propose briefly to discuss some of the problems which arise in connection with gunshot wounds of the knee-joint at the base hospital.

Some of the cases arrive, several days after being wounded, with the foreign body in the joint, either with or without a fracture. Is the foreign body to be removed or to be left in? The answer must depend on the size of the missile and its situation. A foreign body deep in the shaft of the femur, or in a condyle, or the head of the tibia, in a case where the joint is quiescent, can well be left alone. Where there is a large foreign body free in the joint, or protruding out of the bone into the joint cavity, it must be removed.

The question then arises: Should the missile be removed at once, or should an expectant attitude be adopted, and the foreign body removed weeks or months later when the joint is 'quiet'? It is impossible, of course, to make an absolute rule, but my practice has been to remove any such foreign body of large size immediately. The operative procedure has included excision of

the track, employment of a fresh set of instruments for the removal of the foreign body, a gentle mechanical flushing of the area in which it lay, the placing of a small quantity—about 15 grains—of bismuth, iodoform, and paraffin paste into the joint and, whenever possible, the suturing of the capsule and the entire closing of the wound. Special attention should be paid to any bone injury, and after careful curettage, B.I.P.P. is placed in the resulting bone cavity.

The other most frequent, or at any rate most pressing, problem at the base is the treatment of cases of general arthritis of the streptococcal variety. Such cases, when treated by a posterior drainage operation—more especially when there was a bone lesion—did badly in my hands, and in the present series I have attempted resection of the joint rather than this form of drainage. The resection includes the patella, but all the synovial membrane possible is left to act as a protective barrier. After resection, the operation area is treated with B.I.P.P., extension is applied, and a gauze pack is placed between the bone ends. After a lapse of some three to seven or even ten days, depending on the pulse-rate and general condition of the patient, the pack is taken out under nitrous-oxide anæsthesia, the extension removed, and the bony surfaces are allowed to come together. Some cases, after the removal of the pack, have required irrigation daily for suppuration about the resection; but with the exception of two cases amputated, to which I shall refer later, this has cleared up, and bony union has resulted. Fixation after resection is important. There is a tendency for the lower end of the femur to slide outwards so that this bone and the tibia are not in the same straight line. This displacement can be overcome by the use of a short Robert Jones crab splint, in which the limb rests, and which is itself placed on a Thomas hip splint. For this suggestion I am indebted to Captain R. C. Harkness. Osteomyelitis has not supervened in any of the cases.

I am only too well aware that resection performed later than the third or fourth day is a 'second best' operation; the ideal procedure would be so to treat every case at the clearing station that secondary resection would be unnecessary. This notwithstanding, it would appear that in the case of a severe streptococcal infection—especially in the presence of a bone lesion—resection gives a more certain result than does posterior drainage.

It would appear to me that in any case where there is a general acute streptococcus infection and a bone lesion, resection is a justifiable operation; and even in the cases where there is an acute infection of the long-chain streptococcus variety and no bone injury, the possibility must be considered of resection being a wiser operation than drainage, even when the latter is carried out by means of Campbell and Woolfenden's method, with division of the heads of the gastrocnemius (*vide Lancet*, 1917, Aug. 11, 185).

Acute arthritis due to the staphylococcus group can easily be treated by simple drainage methods. Where there is no bone injury, simple incision usually suffices; if there is a bone injury, Carrel-Dakin treatment to the site of such injury gives the best results.

Cases of pure *B. perfringens* infection of the joint are very amenable to treatment; usually, after foreign-body removal and lavage, these joints can be sutured.

Pyæmic infection of the knee-joint by the streptococcus or other organism can be successfully treated by incision, mechanical lavage, the application of 15 gr. of B.I.P.P., suture of the capsule, and skin closure.

Aspiration has given bad results in my hands, both in 1916 and in the few cases thus treated in this series. If the effusion is sterile, it must be regarded as a protective effusion and left alone; if it is infected, it must be evacuated. Aspiration should not be used as a curative measure. Every effusion is needled for diagnostic purposes, and if sterile, is left alone to be absorbed, being considered a protective effort on the part of the joint. Non-absorption does not occur.

It seems necessary to repeat what several other observers have noticed, namely, that absolute immobility is necessary. The fewer the dressings the better. Any operative procedure, short of resection, should be carried out without removing the limb from the splint. Every case of wound in the joint is best treated, for a time at any rate, on a Thomas splint with a fixed extension, using pulleys or not for the splint itself, as may seem advisable.

Starting pains at night are an indication for tightening the extension. At first, if the joint appears quiescent and no pain is complained of, the limb is placed on the splint, and the extension bands are applied, but not tightened; as soon as the knee 'jumps,' the bands must be tightened. Small plates of perforated zinc laid on cross-ribbons of aluminium are the best supports, as they can be easily changed and the skin attended to by the ward sister with the minimum of movement. A Balkan support is necessary.

CONCLUSIONS.

1. Early operation, if the procedure be radical, and especially if the entire capsule can be sutured, results, in 94 per cent of the cases, in a sterile joint, and therefore in a successful issue.

2. Where a pack or drain is used down to a tear in the capsule or to a cavity in bone, the results can never be depended upon.

3. The removal of missiles from the joint within the first week, even in the presence of sepsis (other than that due to the streptococcus), can be followed by immediate suture, B.I.P.P. being used to aid sterilization.

4. The Carrel-Dakin method is most useful for the treatment of bone lesions or septic peri-articular conditions. It is almost impossible to sterilize a severely infected joint by this method.

5. In the presence of a general infection of the joint by the streptococcus, resection gives good results, even when performed in the second or third week.

6. Cases with a severe bone injury should be treated more often than they are by an immediate primary resection of the joint at the clearing station.

[The semi-diagrammatic figures illustrating the article are made from the outlines of x-ray plates.—ED. SEC.]

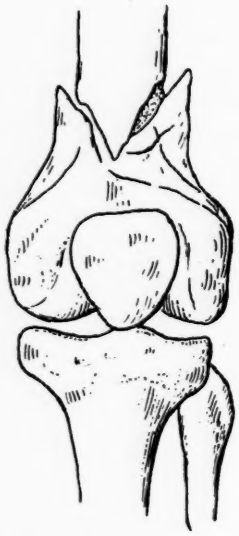

FIG. 363. — *Case* 3. Rifle-bullet wound. Severe comminuted fracture of femur above condyles.

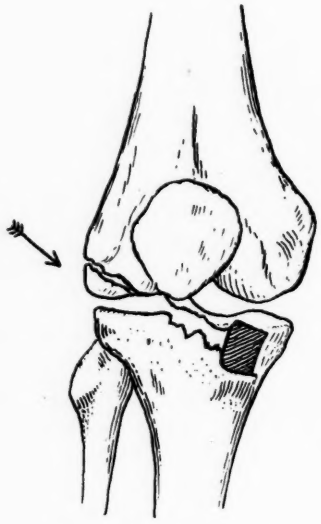

FIG. 364. — *Case* 6. Large high-explosive fragment passed through condyle and joint and lodged in head of tibia.

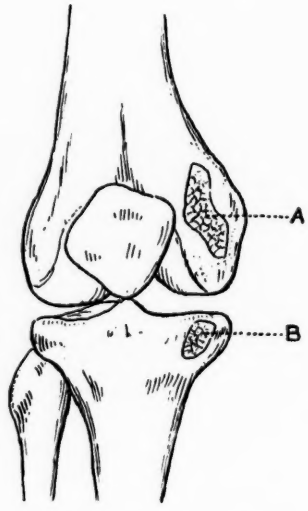

FIG. 365.—*Case* 9. Wound by high-explosive fragment, exposing cancellous tissue of internal condyle and inner head of tibia. A. Cavity in femur. B. Cavity in tibia.

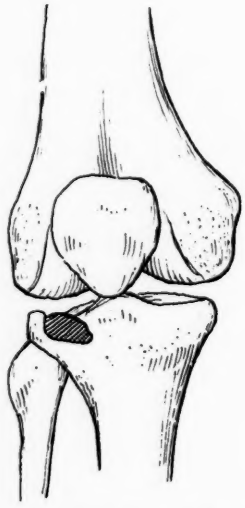

FIG. 366.—*Case* 10. High-explosive fragment in outer head of tibia after passing through joint.

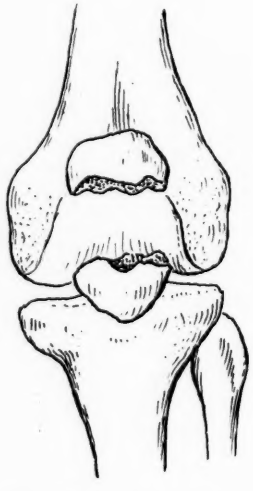

FIG. 367. — *Case* 13. Patella completely divided by high-explosive fragment.

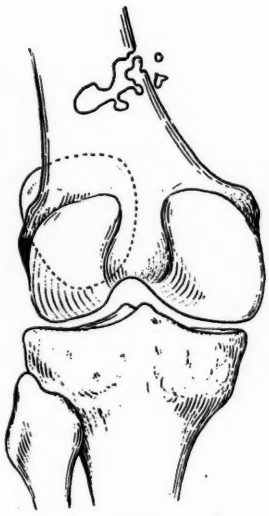

FIG. 368.—*Case* 16. Partial fracture of shaft of femur by machine-gun bullet.

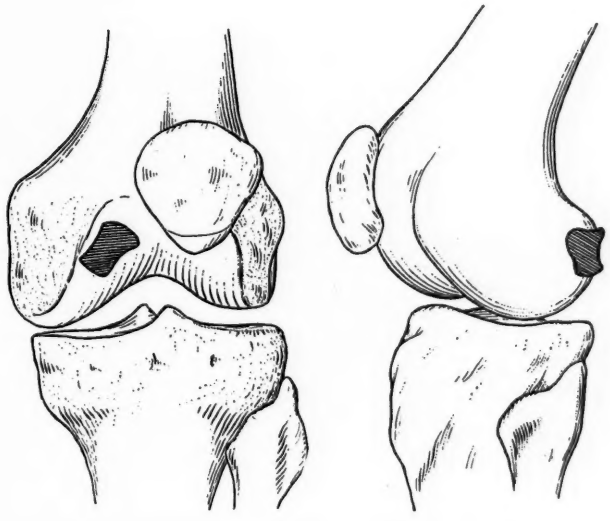

FIG. 369.—*Case* 21. High-explosive fragment lodged in internal condyle of femur posteriorly.

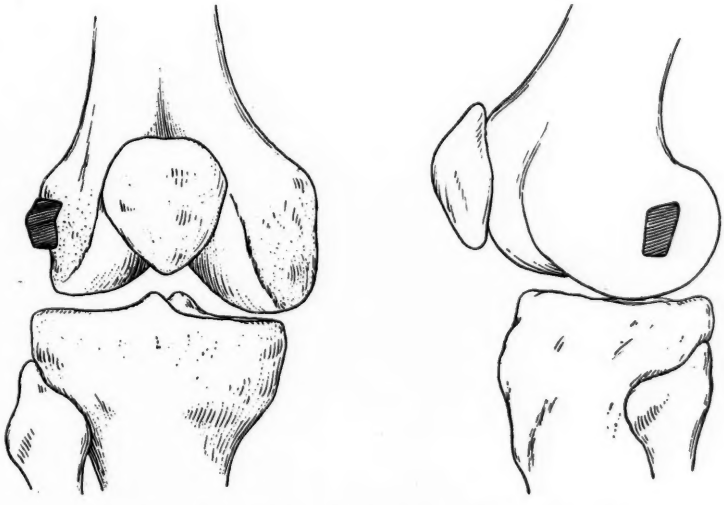

FIG. 370.—*Case* 24. High-explosive fragment found loose in joint at operation.

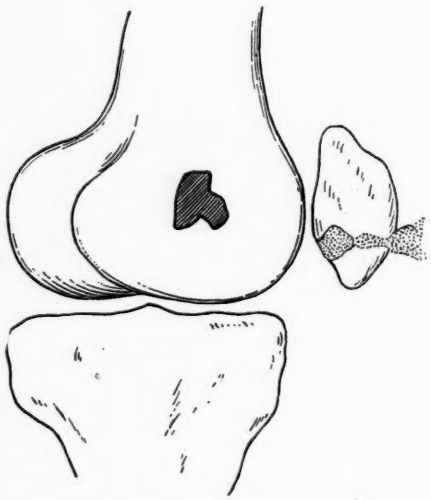

FIG. 371.—*Case* 26. Large high-explosive fragment lying in internal condyle of femur. B.I.P.P. in superficial track.

FIG. 372.—*Case* 46. Fracture of patella by a large high-explosive fragment. The missile has been removed.

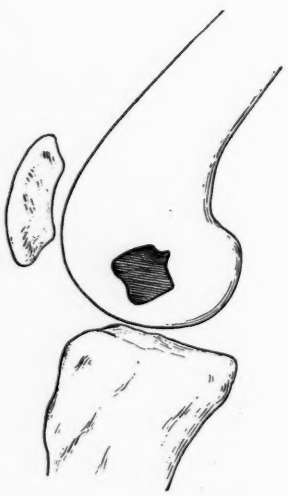

FIG. 373.—*Case* 51. Large high-explosive fragment lodged in intercondylar notch.

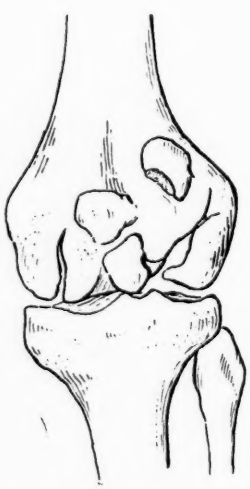

FIG. 374.—*Case* 55. Fracture of patella and both condyles by high-explosive fragment.

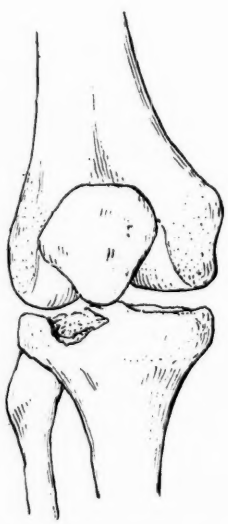

FIG. 375.—*Case* 56. Fracture of outer head of tibia by rifle bullet.

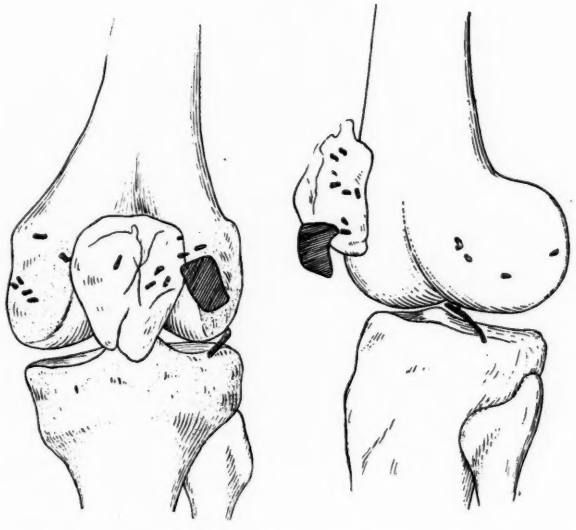

FIG. 376.—*Case* 57. Fracture of patella by revolver bullet, showing bullet and many fragments of lead in joint.

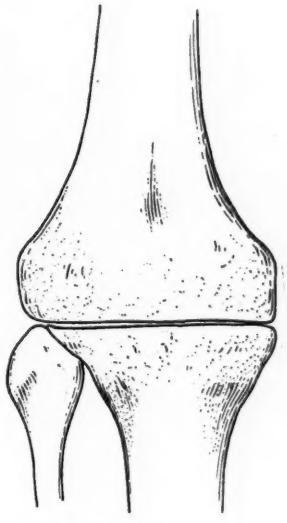

FIG. 377.—*Case* 79. Resection of joint after high-explosive shell wound.

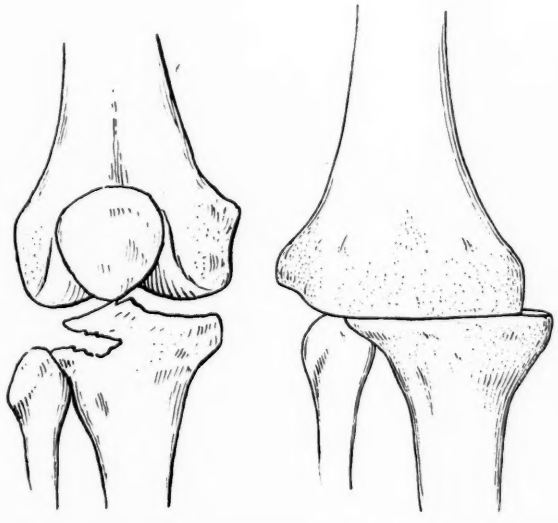

FIG. 378.—*Case* 61. Fracture of tibia by high-explosive fragment which traversed the joint and lay deeply in the outer head. The left-hand illustration shows the joint after removal of the fragment and before resection, the right-hand one the joint after resection, and the outward displacement of the femur which followed it.

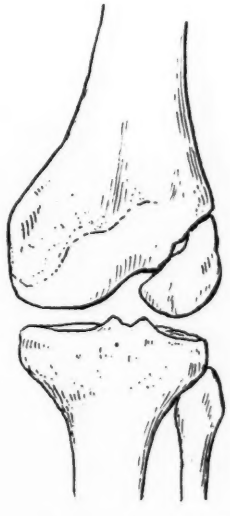

FIG. 379. — *Case* 82. Complete fracture of external condyle by high-explosive fragment.

CASES OF RESECTION OF THE KNEE-JOINT.

Case No.	Nature of Injury	Preliminary Operative Measures	Days from Wounding to Resection	Organisms Found	Result
10	High-explosive fragment lodged in outer head of tibia	Removal on 4th day	8	Streptococcus	Walking well without support
19	Shrapnel ball lodged in external condyle	Removal on 4th day; bony cavity treated with B.I.P.P.	10	Streptococcus	Amputation
20	Large tear of the capsule, exposing condyle and patella	Drainage and irrigation with Dakin's solution 4th day	19	Streptococcus	Amputation
23	Large tear of vastus externus and small perforation of joint capsule	Drainage and lavage 6th day	8	Streptococcus	Good bony union on evacuation. Walking well without support
35	Multiple high-explosive shell wounds into the knee-joint	Aspiration and injection of formalin and glycerin 11th day. Ditto 12th day. Lateral and posterior incisions for drainage 14th day. Carrel-Dakin treatment	37	Streptococcus	Evacuated to England with bony union. Now discharged from the army and walking well; 2 in. of shortening
51	High-explosive fragment lodged in inter-condylar notch with fracture of condyles	Nil	3	*B. perfringens*	Bony union on evacuation
61	High-explosive fragment lodged in head of tibia	Removal 10 hours after wounding. Treatment with B.I.P.P. and pack	5	Streptococcus	Had fibrous union on evacuation. (See *Fig.* 378)
78	Compound comminuted fracture of both condyles	Nil	7 hours	(?)	Evacuated to England with fibrous union
79	Large wound outside and above right patella. Capsule torn. High-explosive fragment lodged in external condyle	Casualty clearing station failed to find. Removal 4th day	48	1. *B. perfringens* 2. Secondary mixed infection	Good alinement and fibrous union on evacuation. (See *Fig.* 377)
82	Complete fracture of external condyle	Removal of condyle 9th day	12	Streptococcus	Fibrous union
95	Fragment lodged in anterior surface of internal condyle. Wound of entrance in popliteal space	Removal of fragment on 2nd day	18	*Staphylococcus aureus*	Evacuated to England in good position with fibrous union

CASES AMPUTATED.

CASE No.	NATURE OF LESION	ORGANISMS FOUND	EARLY TREATMENT	REASONS FOR AMPUTATION	RESULT
19	Shrapnel ball lodged deeply in external condyle	Strepto-cocci	Shrapnel ball removed 5th day. Resection of joint 11th day	Patient developed confusional insanity with melancholia. Amputation performed, as he was considered to be a bad subject for the lengthy treatment necessitated by resection	Evacuated with clean amputation stump
20	Large lacerated wound to outer side of knee-joint, with exposure of external condyle and patella. Multiple wounds of calf	Strepto-cocci	Excision of wound and Carrel-Dakin treatment at casualty clearing station on same day as wound. Joint involvement not appreciated. On 4th day, when at base, multiple incisions in calf for *B. perfringens* infection. High-explosive fragment removed. Joint irrigated. Resection on 20th day. Amputation 39th day	Necrosis of bared lower end of femur was the ground for amputation. Possibly a higher section of the femur might have resulted in successful resection	Stump healed on evacuation
30	High-explosive fragment traversed patella, fracturing external condyle, and also outer head of tibia	(?)	Resection of patella. Wide removal of damaged bone. Treatment with B.I.P.P. and pack on same day as wound. 7th day, when at base, pack removed. 23rd day, sequestra removed. 25th day, amputation	Chronic osteomyelitis of shaft of femur and head of tibia	Amputation stump healed
41	Large lacerated area of muscle on inner side of right knee-joint. Wound of chest wall and compound fracture of left clavicle	Strepto-cocci	The clearing station surgeon excised the lacerated tissue, but failed to observe involvement of knee-joint. 5th day, when at base, joint opened by lateral and posterior incisions. Flavine irrigation. Capsule not sutured. On 8th day, amputation. 11th day, death	Extreme degree of sepsis	Post-mortem examination revealed duodenal ulcer, with a severe hæmorrhage
55	Penetration of the left knee-joint by high-explosive fragment; with compound fracture of both condyles	Strepto-cocci	2nd day, removal of foreign body and portion of external condyle; Carrel-Dakin treatment. 18th day, when at base, amputation	General condition very poor. Extensive tracking of pus both up the thigh and down the calf	Amputation flaps still open on evacuation
56	Rifle bullet entered to outer side of right patella, fractured outer head of tibia, and emerged low in popliteal space	Strepto-cocci	Joint opened on 8th day at clearing station by anterior incisions. Eusol lavage. B.I.P.P. applied and capsule sutured. Wound of exit enlarged slightly. 25th day, when at base, posterior drainage, with division of outer head of gastrocnemius. 28th day, amputation. 30th day, direct transfusion of 650 c.c. blood. 35th day, evacuation of pyæmic abscess of left knee-joint. 41st day, evacuation of pyæmic abscess of left shoulder-joint. 44th day, death	Immediate amputation on admission was considered advisable, but patient absolutely refused. It was only two days after the posterior drainage operation that he consented to amputation	At the post-mortem, osteomyelitis of the shaft of the femur was found, and some pus in the left shoulder-joint. The left knee-joint appeared clean

PARTICULARS

Case No.	Date of Wound	Missile	Nature of Injury	Organisms Found	Treatment at Casualty Clearing Station
1	23.3.17	High-explosive fragment the size of a split pea	Fragment entered to the outer side of the left patella, traversed the suprapatellar pouch, and lay in the quadriceps	—	Wound excised. Joint irrigated and closed. Fragment not found. B.I.P.P. applied. Wound closed
2	28.2.17	Rifle bullet	Foul-smelling transverse wound, laying open the front of the right knee-joint and fracturing the patella. Much pus in the cancellous tissue of the patella and in the joint	Streptococci	Salt pack
3	14.2.17	Rifle bullet	Through-and-through wound. Entrance 1 in. above and to the inner side of the left patella. Exit to outer side of popliteal space. Severe comminution of femur above condyles. (See *Fig.* 363)	—	Back splint
4	21.3.17	High-explosive shell	Through-and-through wound of left supra-patellar pouch. Entrance above and to outer side of patella. Exit through biceps femoris	—	Track excised. Entrance wound sutured. Exit wound packed
5	20.3.17	High-explosive shell	Penetrating wound, outer side of left knee. Fragment lying in supra-patellar pouch	—	Wound excised. Foreign body removed. Joint lavage. Suture of capsule. B.I.P.P. applied. Skin suture
6	28.3.17	High-explosive shell	Large fragment perforated the right external condyle, traversed the joint, and lodged in the inner head of the tibia. (See *Fig.* 364)	—	Wound of entrance excised, external condyle trimmed, and fragment removed from inner head of tibia. Joint lavage and treatment of wound with B.I.P.P. Complete closure
7	28.3.17	High-explosive shell	Fragment entered right suprapatellar pouch externally	—	Wound excised. Fragment removed. Eusol lavage. Capsule sutured. B.I.P.P. applied. Skin closure
8	27.3.17	High-explosive shell	Large entry wound, 8 in. long, on outer side of right thigh. Fragment lay on internal condyle. Large tear of joint capsule	Streptococci	Large area of vastus externus and quadriceps excised for gas gangrene. Counter-incision made over internal condyle. Fragment removed. Drainage tube, ½ in. in diameter, passed through the joint. Massive salt pack applied
9	31.3.17	High-explosive shell	Entrance above and to inner side of right patella, entering joint, exposing cancellous tissue of internal condyle and of the inner head of the tibia. (See *Fig.* 365)	—	Excision of wound. Condyle laid bare. Salt pack
10	9.4.17	High-explosive shell	Entrance wound at level of centre of right knee-joint externally. High-explosive fragment lodged in outer head of tibia, traversing joint and cartilage on its way. (See *Fig.* 366)	Streptococci	Nil

OF CASES.

TIME FROM RECEIPT OF WOUND TO OPERATION	TREATMENT AT BASE	COMPLICATIONS	CONDITION ON EVACUATION	RESULT
Same day	Extension and Thomas splint applied	Nil	10.4.17. No effusion. Temperature normal. Wound healed. Fragment *in situ*	—
Six days	6.3.17. Resection of the patella. Operation area douched with saline. 15 gr. of B.I.P.P. applied. Partial suture	24.3.17. Small extension abscess in vastus externus	24.4.17. Wound granulating. No discharge. No effusion. Temperature and pulse normal	Stiff knee
—	Thomas splint and extension applied	Nil. Sequestra removed in England	15.4.17. Bony union in good position. Wounds still discharging	Can flex knee to a right angle
Same day	Pack removed	—	8.4.17. No effusion. Wounds granulating. Suture line healed. Temperature normal	—
Same day	Nil	Nil	8.4.17. Wound healed. No effusion	—
One day	Extension applied	Nil	Wound healed by first intention. Temperature and pulse normal	6.6.17. Some mobility of joint. Walking without crutches
One day	14.4.17. Abscess outside the joint opened	Extensive abscess in vastus externus	18.4.17. No effusion. Wound granulating. Temperature normal	—
One day	Salt pack removed. Large quantity of pus tracking in every direction. 3.4.17. Operation. Wounds cleansed. Carrel's tubes placed in position. 25.4.17. Counter-opening on inner side of thigh for continued suppuration	Through-and through wound of right loin. Collapse of both lung bases	18.5.17. Wounds granulating. Temperature normal	27.8.17. Stiff knee. Walking well
Same day	Pack removed. Carrel-Dakin treatment for three weeks	Nil	7.5.17. Wound granulating. Temperature normal	Wound healed. Mobility to 40°. Walks well
Four days	13.4.17. High-explosive fragment removed. Cavity treated with B.I.P.P. 16.4.17. Resection of knee-joint	Nil	11.5.17. Wound healed except at external extremity of incision. Bony union	19.7.17. Ankylosed knee. Good result. Still using crutches. 4.9.17. Walking without crutches

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PARTICULARS OF

Case No.	Date of Wound	Missile	Nature of Injury	Organisms Found	Treatment at Casualty Clearing Station
11	9.4.17	High-explosive shell	Large spear-shaped fragment perforated right knee-joint just below patella, and remained protruding through skin. Removed at field ambulance	*Staphylococcus aureus*	Joint opened and fragment searched for (through an error). Formalin and glycerin injected. Skin sutured
12	9.4.17	Machine-gun bullets	Right knee: entrance wound below and behind head of fibula; exit wound in front of the internal condyle; fracture of condyle, and joint traversed. Left knee: through-and-through anteroposterior wound, entrance anteriorly; fragments of head of fibula blown out through posterior wound; left knee-joint not involved, unless through communication with fibular articulation	—	Salt packs and excision of track. B.I.P.P. to internal condyle. Wound packed. Remainder of wound sutured. B.I.P.P. applied to fractured remains of head of left fibula. Pack applied
13	9.4.17	High-explosive shell	Large irregular gangrenous wound over left knee-joint, with patella completely divided and lying in a pool of pus. (See *Fig.* 367)	Streptococci	Salt pack
14	11.4.17	High-explosive shell	Capsule of left knee-joint torn by fragment of high-explosive shell which penetrated ligamentum patellæ. Fragment fell out after tearing capsule	Sterile effusion	Splinting
15	14.4.17	High-explosive shell	Entrance wound behind head of right fibula. Exit external to patella anteriorly. Laceration of external condyle.	—	(Notes lost.) Anterior exit wound excised and sutured, evidently
16	28.4.17	Machine-gun bullet	Entrance and exit wounds of right suprapatellar pouch. Femur fractured in its inner half but without complete loss of continuity. (See *Fig.* 368)	—	Wounds excised. Capsule sutured. Entrance wound closed. Exit wound packed down to bone
17	14.4.17	Machine-gun bullet	Anteroposterior penetrating wound of left femur above condyles, with two fissures radiating upwards. Entrance 1 in. above patella; exit, popliteal space at same level. Suprapatellar pouch involved	—	Splinting
18	29.4.17	Rifle bullet	Entrance wound just above left patella near mid-line. Bullet lodged in shaft of femur	Exudate sterile	Splinting
19	28.4.17	Shrapnel ball	Entrance wound to outer side of left knee. Ball traversed joint and lodged deeply in external condyle	Streptococci	Nil

CASES—*continued.*

TIME FROM RECEIPT OF WOUND TO OPERATION	TREATMENT AT BASE	COMPLICATIONS	CONDITION ON EVACUATION	RESULT
Same day	Hyperchlorous washing after removal of stitches	Copious purulent exudate	7.5.17. Small sinus. Temperature normal	25.8.17. Mobile joint. Walks well. 19.9.17. "Will be fit for service in two months"
Two-and-a half days	21.4.17. Salt pack replaced, and again on 26.4.17	Nil	30.4.17. Wound healed, excepting track to internal condyle where fracture lies. Temperature normal. No effusion	—
Three days	Resection of patella. Gangrenous tissue excised. Pus swabbed out of joint and eusol douche used. 15 gr. of B.I.P.P. applied. Partial suture	Chronic suppuration about suture line	28.5.17. Wounds granulating. Temperature normal	28.8.17. Knee stiff. Is walking well
Five days	Wound excised. B.I.P.P., gr. 15, placed in joint. Capsule sutured. Wound closed	High-explosive fragment removed from cavity in left hamstrings	30.4.17. No effusion. Wound healed	12.9.17. Some degree of mobility. Still under treatment
One and a half days	Nil	Entrance and exit wounds of left thigh	26.4.17. No effusion. Wound healed	3.9.17. "Very limited movement in knee; a useful limb"
Eighteen hours	Repacked	Nil	10.5.17. Wound granulating. No effusion	—
—	Nil	—	20.4.17. Temperature normal. No effusion	3.8.17. A perfectly mobile knee-joint. No shortening of limb. Re-classified C3
—	Operation performed owing to *x*-ray error. Bullet reported in joint, whereas it was in femur. Joint closed. Bullet not removed	—	25.5.17. Wound healed. No effusion. Temperature normal	24.8.17. Good movable joint
Three days	1.5.17. Ball removed. Cavity cleansed. B.I.P.P. applied. Partial suture. 7.5.17. Resection of joint. 24.5.17. Amputation	Patient developed confusional insanity with melancholia. Amputation was done because he was considered to be a bad subject for the lengthy treatment which a resection necessitates	Stump clean	Amputation

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PARTICULARS OF

CASE NO.	DATE OF WOUND	MISSILE	NATURE OF INJURY	ORGANISMS FOUND	TREATMENT AT CASUALTY CLEARING STATION
20	15.4.17	High-explosive shell	Large laceration to outer side of right knee-joint. Condyle and patella exposed. Multiple wounds in calf	Strepto-cocci	Carrel-Dakin, but the fact that the joint was involved was not appreciated
21	3.5.17	High-explosive shell	Entrance wound to inner side of left internal condyle. High-explosive fragment the size of a shilling lying in joint behind internal condyle, which had its cartilage torn. (See *Fig* 369)	—	Nil
22	3.5.17	Rifle bullet	Entrance wound below and internal to inner head of left tibia. Traversed head of left tibia and found exit via ligamentum patellæ ; joint penetrated	—	Nil
23	3.5.17	High-explosive shell	Large area of skin removed on outer side of right knee-joint by high-explosive fragment. Vastus externus lacerated. Joint penetrated by a tear of the capsule	Strepto-cocci	Wound cleansed. Penetration of knee-joint not discovered
24	9.5.17	High-explosive shell	Entrance wound to outer side of right knee 1 in. above head of fibula. Large fragment lying posterior to external condyle. (See *Fig.* 370)	—	Nil
25	5.5.17	High-explosive shell	Severe compound fracture of left patella with penetration of joint	—	Resection of patella. Irrigation of joint. Salt pack
26	9.5.17	High-explosive shell	Entrance wound internal to centre of left patella the size of a sixpence. Large high-explosive fragment lying deep in internal condyle. (See *Fig.* 371)	*B. per-fringens*	Packing placed in track with B.I.P.P. No operative procedure
27	9.5.17	High-explosive shell	Through-and-through wound of left knee, with compound fracture of outer articular half of external condyle	—	Excision of track. B.I.P.P. placed in joint. Suture of capsule. Wound closed
28	3.5.17	High-explosive shell	Minute wound to inner side of left patella. High-explosive fragment lying in joint	—	Removal of high-explosive fragment. Joint treated with 2 per cent formalin and glycerin. Capsule sutured. Wound closed
29	19.5.17	High-explosive shell	Wound to inner side of right knee. Fragment lying in infrapatellar pouch to outer side of joint	Effusion sterile	Joint opened widely. Foreign body removed. Saline douche. B.I.P.P. applied. Capsule sutured. Skin closure

CASES—*continued.*

Time from Receipt of Wound to Operation	Treatment at Base	Complications	Condition on Evacuation	Result
Same day	18.4.17. Multiple incisions in calf. High-explosive fragment removed. Carrel-Dakin treatment continued. 4.5.17. Resection. 23.5.17. Amputation	Necrosis of the bared shaft of the femur was the ground for amputation; possibly a wider removal of the femur might have been successful	Stump healed	Amputation
Three days	Removal of high-explosive fragment through posterior incision. B.I.P.P., gr. 15, placed in joint. Capsule sutured. Original wound excised	Nil	31.5.17. Temperature normal. No effusion. Wound healed	28.8.17. Is walking. Some mobility. Still having massage. 12.9.17. "He has a good mobile knee-joint, but not perfect"
—	Splinting	—	9.5.17. Temperature normal. No effusion	Flexion to a right angle. Good functional limb. Is back with his regiment
Five days	8.5.17. Lateral incisions into joint, and eusol wash. B.I.P.P., gr. 15, placed in joint. 10.5.17. Resection of joint	3.6.17. Secondary abscess in supra-patellar pouch	6.7.17. Bony union. Wounds granulating	12.9.17. Is walking, but still uses sticks. 10.10.17. Is walking well without aid
Three days	Removal of foreign body. B.I.P.P., gr. 15, placed in joint. Suture of capsule. Wound closed	Nil	7.6.17. Wound healed. No effusion. Temperature normal	28.8.17. Mobile knee, but still on crutches
Same day	19.5.17. Carrel-Dakin treatment. Counter-incision at apex of Scarpa's triangle	—	17.6.17. Wounds granulating. Temperature normal	Stiff knee
Three days	High-explosive fragment removed. Cavity in condyle cleansed. B.I.P.P., gr. 15, applied. Suture of capsule and of wound	Lacerated wound of left deltoid and biceps; also wound of face	8.6.17. Wound healed. No effusion. Temperature normal	—
Same day	Nil	Superficial wounds of left chest and buttock	6.6.17. Wound healed. No effusion. Temperature normal	—
Two days	Nil	Nil	28.5.17. Wound healed. No effusion. Temperature normal	—
Same day	Splint and extension applied	Nil	14.6.17. Wound healed. No effusion. Temperature normal	Developed femoral thrombosis after first massage in England. 3.9.17. Still in bed

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PARTICULARS OF

Case No.	Date of Wound	Missile	Nature of Injury	Organisms Found	Treatment at Casualty Clearing Station
30	25.5.17	High-explosive shell	High-explosive fragment traversed left patella, fracturing the external condyle and outer head of tibia	—	External wound excised. Lateral meniscus removed. Damaged bone chiselled away. Patella removed. Area treated with B.I.P.P. Pack externally. Remainder of wound closed
31	28.5.17	High-explosive fragment, 3in. × 5in.	Ligamentum patellæ and joint capsule torn. Fragment fell on the ground	—	Wound excised. Track treated with B.I.P.P. and sutured
32	2.6.17	Machine-gun bullet	Through-and-through wound of right knee-joint, traversing both condyles and causing a fissured fracture into the joint	—	Entrance wound excised down to bone. Joint washed out and closed. Area treated with B.I.P.P. Exit wound packed down to bone
33	3.6.17	High-explosive shell	High-explosive fragment the size of a pea lay in left suprapatellar pouch. Entrance wound above and outside left patella	Diphtheroid bacillus	Nil
34	28.2.17	High-explosive shell	Multiple wounds of left thigh, both buttocks, both legs, both knee-joints. All wounds small	Effusion sterile	Nil
35	13.12.16	High-explosive shell	Multiple minute penetrating wounds about left knee-joint	Streptococci	Splinting. This case was treated by aspiration and by injection of iodoform and glycerin up to 26.12.16
36	4.2.17	High-explosive shell	Compound fracture of left internal condyle involving joint	—	Joint washed out with saline. Comminuted bone removed. Capsule sutured. Salt pack down to fracture
37	8.2.17	High-explosive shell	High-explosive fragment penetrated left knee-joint, fracturing patella and lying in head of tibia	—	Joint washed out with eusol. Capsule sutured after removal of foreign body. Salt pack down to tibial wound
38	10.2.17	High-explosive shell	Entrance wound to inner side of left knee-joint. Fragment lying postero-internally to internal condyle	—	Joint explored. Foreign body not found. Eusol and ether wash out. Suture of capsule. Wound closure
39	8.2.17	Bullet	Through-and-through wound of suprapatellar pouch, with compound fracture of right femur	Nil	Wounds enlarged
40	(?)	Shrapnel ball	Entrance wound 1 in. above centre of right patella. Shrapnel ball lying at level of joint centre under external lateral ligament	Nil	Splint applied

CASES—*continued.*

TIME FROM RECEIPT OF WOUND TO OPERATION	TREATMENT AT BASE	COMPLICATIONS	CONDITION ON EVACUATION	RESULT
Nineteen hours	31.5.17. Plug removed. 16.6.17. Dead bone removed from head of tibia and condyle. 18.6.17. Amputation	Chronic osteomyelitis of shaft of femur, necessitating amputation	Stump healed	Amputation
Twenty-three hours	Splint and extension applied	Nil	12.6.17. Wound healed. Temperature normal. No effusion	Mobile joint. Wears a bandage, but walks very well
Three and a half hours	Repacked	Nil	25.6.17. No effusion. Pack still in outer portion of wound. Suture line healed elsewhere	—
Two days	High-explosive fragment removed. Joint washed out. B.I.P.P., gr. 15, applied. Capsule sutured. Skin closure	13.6.17. An abscess outside the joint was opened	29.6.17. Temperature normal. No effusion. Wound granulating	—
Four days	4.3.17, 5.3.17, and 8.3.17. Multiple incisions for gas gangrene. Both joints aspirated	*B. perfringens* infection of the flesh wounds	No effusion. All wounds granulating	Right thigh amputated in England. Still in hospital. No report as to reason for amputation
Thirteen days	26.12.16. Posterior and lateral drainage. Carrel-Dakin treatment. 19.1.17. Resection of joint	Nil	7.3.17. Wounds granulating. Temperature normal	10.10.17. Back at old employment. Walks well. Two inches of shortening
—	Thomas splint and extension applied	Nil	8.3.17. Wound granulating. No effusion. Temperature normal	—
Same day	Thomas splint and extension applied	Nil	All wounds healed	12.8.17. Fair mobility. Doing light duty with reserve battalion
Same day	Nil	Entrance and exit wounds posterior cervical region. Foreign body *in situ*	Wound healed. Temperature normal. No effusion	—
(?)	26.2.17. Wounds further enlarged. Carrel-Dakin treatment of joint	Prolonged sepsis	Wounds granulating. Bony union. No effusion	—
Three days	Shrapnel ball removed. Joint treated by Campbell's method of posterior drainage and with Carrel-Dakin solution	Nil	Wounds healed. No effusion. No temperature	12.7.17. Good result. Flexion to a right angle. Doing duty with reserve battalion

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PARTICULARS OF

CASE NO.	DATE OF WOUND	MISSILE	NATURE OF INJURY	ORGANISMS FOUND	TREATMENT AT CASUALTY CLEARING STATION
41	7.6.17	High-explosive shell	Large lacerated area of muscle laid open on inner side of right knee-joint. Wound of chest wall, and compound fracture of left clavicle	Strepto-cocci	The tear of the capsule was not observed at the casualty clearing station. Large area of tissue, 6 in. × 4 in., over inner side of joint was excised, and B.I.P.P. applied
42	7.6.17	Shrapnel ball	Entrance wound in centre of left popliteal space. Ball lodged in internal condyle	Effusion sterile	Nil
43	7.6.17	Shrapnel ball	Entrance wound outside and below left patella. Shrapnel ball lying to inner side of joint	Effusion sterile	Ball removed. Joint irrigated. Capsule sutured. Entrance wound excised
44	3.6.17	High-explosive shell	Many minute fragments in right knee-joint, right ankle-joint, and leg	Effusion sterile	Several fragments removed from knee-joint, one from head of tibia, and one from head of fibula. Wounds left open
45	24.4.17	High-explosive shell	Compound fracture of right patella, with separation of fragments. Compound fracture of left tibia and fibula. Flesh wounds of left thigh	—	Suture of patella. Carrel-Dakin treatment
46	8.6.17	High-explosive shell	Compound fracture of right patella, with penetration of a large high-explosive fragment. (See *Fig.* 372)	—	Foreign body removed. Joint washed out with eusol. Capsule sutured. Pack down to patella
47	2.6.17	High-explosive shell	Through-and-through wound of right suprapatellar pouch	—	Wounds enlarged. Carrel-Dakin treatment
48	6.6.17	Shrapnel ball	Entrance below and internal to right patella. Exit in region of adductor tubercle	Effusion sterile	Excision of wounds (?). No notes
49	7.6.17	Shrapnel ball	Entrance wound below and to outer side of the right patella. Ball traversed joint and lay in vastus externus at a higher level	Effusion sterile	Nil
50	8.6.17	Rifle bullet	Entrance wound 2 in. above upper border of left patella in mid-line. Exit at a level 3 in. lower and slightly internal, in the popliteal space. *X* rays show nil	Effusion sterile	Nil
51	8.6.17	High-explosive shell	Entrance wound internal to centre of left patella. Large high-explosive fragment buried deeply in intercondylar notch. (See *Fig.* 373)	*B. per-fringens*	Nil
52	14.6.17	High-explosive shell	Through-and-through wound to inner side of right knee, penetrating the capsule and causing wound of internal condyle outside joint	Effusion sterile	Wounds excised. Joint irrigated. Capsule sutured. B.I.P.P. to bony lesion
53	14.6.17	Rifle bullet	Through-and-through wound of left suprapatellar pouch	—	Thomas splint and extension

CASES—*continued.*

TIME FROM RECEIPT OF WOUND TO OPERATION	TREATMENT AT BASE	COMPLICATIONS	CONDITION ON EVACUATION	RESULT
Five days (to operation at base)	12.6.17. Joint opened on either side of patella. Flavine irrigation. 15.6.17. Amputation of thigh	Duodenal ulcer. Hæmorrhage	—	19.6.17. Death
—	Splint and extension applied	Nil, except that foreign body is *in situ*	30.6.17. Temperature normal. No effusion. Ball *in situ*	—
Ten hours	Nil	Nil	28.6.17. Wounds healed. No effusion. Temperature normal	28.8.17. Some mobility. Still on massage, but walking well
One day	Carrel-Dakin treatment	Mild sepsis of all wounds	27.7.17. Wounds granulating. Normal temperature	12.12.17. Walking, but knee is stiff
Four hours	Continuation of Carrel-Dakin treatment	—	18.6.17. Wounds granulating	3.9.17. Subsequently the patella necrosed. Knee stiff
Three hours	Packs re-applied	Nil	26.6.17. Wound granulating. No effusion. Temperature normal	—
Seven days (lay out)	Continuation of Carrel-Dakin treatment	Nil	30.6.17. Wounds granulating. No effusion. Temperature normal	—
(?)	Splint and extension applied	Nil	26.6.17. No effusion. Temperature normal. Wounds healed	—
Three days	10.6.17. Shrapnel ball removed. Cavity excised and treated by B.I.P.P. Suture	Nil	20.6.17. Wound healed. No effusion. Temperature normal	28.8.17. Good mobile knee. Walks well
—	Splint and extension applied	Nil	26.6.17. No effusion. Temperature normal. Wounds dry	—
Two days	10.6.17. Resection of joint	—	31.7.17. Good bony union. Wound healed. Temperature normal	9.9.17. Walking with crutches
Twelve hours	Nil	Nil	1.7.17. No effusion. Wound healed. Temperature normal	—
—	Nil	Nil	26.6.17. No effusion. Temperature normal. Wounds healed	29.8.17. Good mobile knee-joint

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PARTICULARS OF CA

CASE NO.	DATE OF WOUND	MISSILE	NATURE OF INJURY	ORGANISMS FOUND	TREATMENT AT CASUALTY CLEARING STATION
54	18.6.17	High-explosive shell	Entrance wound in left popliteal space 1½ in. internal to centre. Fragment the size of a pea lying anteriorly over internal semilunar cartilage	*Staphylococcus albus*	Splint
55	13.6.17	High-explosive shell	Penetration of left knee-joint, with compound fracture of patella and both condyles. (See *Fig.* 374)	Streptococci	Removal of foreign body and portion of external condyle. Carrel-Dakin treatment
56	7.6.17	Rifle bullet	Entrance wound to outer side of right patella. Exit low in popliteal space. Fracture of outer head of tibia. (See *Fig.* 375)	Streptococci	Joint opened by anterior incisions and flushed with eusol. B.I.P.P. applied and capsule sutured. Posterior wound enlarged
57	29.6.17	Revolver bullet	Entrance wound fracturing left patella and opening joint. The bullet lay below and outside the patella. Multiple fragments of lead penetrated the joint. (See *Fig.* 376)	—	Casualty clearing station writes: "Wound front of knee excised and enlarged. Patella found to be comminuted. Joint irrigated with saline, ether injected; wound sutured. Counter-incision in popliteal space over round movable body found to be sesamoid in biceps"
58	26.6.17	High-explosive shell	Entrance wound to outer side of left knee, traversing joint. Two small fragments the size of peas lay in the external condyle	—	Entire track excised down to bone. Injured bone gouged away, and foreign bodies removed. B.I.P.P. applied and joint capsule sutured
59	27.6.17	High-explosive shell	Wound over right patella. Compound comminuted fracture of the patella. Joint opened widely	—	Toilet and suture. B.I.P.P. used
60	1.7.17	High-explosive shell	Multiple minute wounds penetrating left knee-joint, right eye, legs, thighs, face, chest wall, and left testicle	—	Joint explored. None of the minute fragments found. Wound closed
61	9.7.17	High-explosive shell	Large fragment entered external aspect of right knee, traversed joint, and lodged deeply in outer head of tibia. (See *Fig.* 378)	Streptococci	Fragment removed. B.I.P.P. applied, with pack into head of tibia
62	5.7.17	High-explosive shell	Entrance wound to outer side of right knee-joint. Joint traversed. High explosive fragment lying in outer condyle under the cartilage	Nil	Fragment removed. Cavity cleansed. B.I.P.P applied. Capsule sutured and wound closed

CASES—*continued.*

TIME FROM RECEIPT OF WOUND TO OPERATION	TREATMENT AT BASE	COMPLICATIONS	CONDITION ON EVACUATION	RESULT
Three days	Foreign body removed by anterior incision. B.I.P.P. placed in the minute cavity in the joint. Capsule sutured. Wound closed	Nil	3.7.17. Wound healed. No effusion. Temperature normal	27.8.17. Full movements of joint
One day	30.6.17. Amputation on account of general ill condition and extensive tracking of pus	—	Stump clean, but flaps not sutured	Amputation
Eight days (lay out four)	1.7.17. Refused amputation, so Campbell's posterior operation performed. 4.7.17. Consented to amputation. Operation performed accordingly. 6.7.17. 650 c.c. of blood by direct transfusion. 11.7.17. Pyæmic abscess of left knee-joint. Joint opened and washed out. B.I.P.P., gr. 15, applied. 17.7.17. Pyæmia in left shoulder-joint. Similarly treated	Pyæmia in left knee- and shoulder-joints. Osteomyelitis of femur in amputation stump	—	20.7.17. Death
Three days	2.7.17. Antero-external incision. Bullet removed. Large tear found in capsule. B.I.P.P., gr. 15, placed in joint. Capsule sutured. Minute leaden fragments not searched for	Nil	25.7.17. Wound healed. Temperature normal. No effusion	7.9.17. Mobile joint. Degree of flexion increasing daily
Twelve hours	Nil	Nil	26.7.17. Wound healed. Temperature normal. No effusion	—
Same day	Nil	Nil	27.7.17. Wound healed. No effusion. Temperature normal	—
Three days	Splinting and extension. Enucleation of right eye. Evacuation of abscess in left tunica vaginalis	—	30.7.17. Wound healed. No effusion. Temperature normal	12.9.17. Mobility improving. Still under treatment
Ten hours	13.7.17. Resection of joint	Abscess in suprapatellar pouch	4.10.17. Fibrous union. Femur has slid outwards on the tibia slightly (see *Fig.* 378). Wounds granulating	—
Eight hours	Extension and splinting	—	20.9.17. Wound healed. No effusion. Temperature normal	—

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PARTICULARS OF

CASE NO.	DATE OF WOUND	MISSILE	NATURE OF INJURY	ORGANISMS FOUND	TREATMENT AT CASUALTY CLEARING STATION
63	7.7.17	High-explosive shell	Superficial wounds of scalp, wrist, arms, and hands. Large fragment of high-explosive shell entered internal condyle of right knee, tearing the capsule; another fragment lay external to capsule of right knee. Compound fracture of toes of right foot. Multiple wounds about left knee-joint; several minute fragments in the joint. Compound fracture of toes of left foot	Effusion sterile in both knees. *B. perfringens* infection of wound outside capsule of right knee	High-explosive fragment removed from internal condyle of right knee. B.I.P.P. applied after cleansing cavity. Pack placed *in situ*. Amputation of toes of both feet. Other wounds cleansed
64	11.7.17	High-explosive shell	Compound fracture of right patella. High-explosive fragment tore capsule and lay in joint	Sterile effusion	Foreign body removed. Joint washed out and filled with ether; B.I.P.P. to patella. Suture of capsule and closure of wound
65	1.3.17	High-explosive shell	Multiple minute fragments penetrating left knee-joint	—	Nil
66	13.7.17	Machine-gun bullet	Entrance wound above and to outer side of centre of patella. Exit through biceps just above its insertion. Was hit while kneeling. No evidence of a fracture. No *x*-ray photograph	—	Back splint
67	5.7.17	High-explosive shell	High-explosive shell wounds of back of neck. Wounds of right leg with fracture of fibula; wound of right knee with injury to external condyle (furrowed); probably a through-and-through wound	—	Foreign bodies removed from neck and leg. None found in knee-joint. Capsule sutured after eusol and ether wash out. B.I.P.P. applied outside capsule. Wound sutured
68	15.7.17	High-explosive shell	Wound over internal condyle of right knee-joint. Capsule opened. Two minute particles in condyle	—	Wound excised. B.I.P.P. applied. Knee-joint not thought to be penetrated
69	24.7.17	High-explosive shell	Minute perforations of right suprapatellar pouch	—	Joint washed out. B.I.P.P. applied. Capsule sutured. Wound excised
70	31.7.17	Shrapnel ball	Entrance wound below and outside right patella. Ball traversed joint and head of tibia, and lay under the skin below inner head of tibia	—	Nil
71	31.7.17	Rifle bullet	Through-and-through wound of right suprapatellar pouch	Effusion sterile	Back splint
72	31.7.17	Shrapnel balls	Entrance wound of right knee-joint on a level with upper margin of patella; ball lodged in external condyle; no evidence of joint penetration. Left knee: Three wounds of entrance clustered above and to inner side of patella; three balls lying above and external to patella outside joint; one traversed suprapatellar pouch, possibly two. Penetration of left tibia, ball lying below and in front of head of fibula	—	Nil

CASES—*continued.*

Time from Receipt of Wound to Operation	Treatment at Base	Complications	Condition on Evacuation	Result
Thirteen hours	13.7.17. High-explosive fragment removed from right knee region, lying outside capsule. Wound to internal condyle enlarged. Carrel-Dakin treatment instituted to this wound	Severe nephritis	17.8.17. Urine 60 to 70 oz. No albumin. Some effusion remains in left knee-joint. Right knee, no effusion. Track to internal condyle remains open	—
Ten hours	Splint and extension applied	Nil	30.7.17. Temperature normal. Wound healed. No effusion	23.8.17. Good mobile joint. Complete flexion
—	Nil	Fragments *in situ*	24.3.17. Wounds dry. Tem. normal. No effusion	—
—	Thomas splint and extension applied	—	23.7.17. Slight effusion. Temperature normal	—
Same day	Nil	—	23.7.17. Temperature normal. No effusion	—
Sixteen hours	Splint and extension applied	Foreign bodies *in situ*	1.8.17. No effusion. Temperature normal. Fragments *in situ*	—
Twenty hours	Nil	—	3.8.17. Suture healed. No effusion. Temperature normal	—
Three days	Removal of shrapnel ball	—	5.8.17. Sutures still in. Effusion diminished. Temperature normal	—
—	Thomas splint and extension applied	Nil	11.8.17. Effusion diminished. Temperature normal	—
Three days	Five shrapnel balls removed. B.I.P.P. applied and wounds left open. Joint treated expectantly	—	18.8.17. Wounds granulating. Temperature normal. No effusion	—

Continued on next page

PARTICULARS OF

Case No.	Date of Wound	Missile	Nature of Injury	Organisms Found	Treatment at Casualty Clearing Station
73	31.7.17	High-explosive shell	Missile traversed left suprapatellar pouch and entered the right leg below and behind the abductor tubercle, lodging in biceps tendon	—	Nil
74	31.7.17	High-explosive shell	Multiple high-explosive shell wounds about left knee-joint. One small fragment lies in joint	—	Joint explored after excision of one wound. Nothing found. Capsule sutured. Wound closed
75	5.8.17	Shrapnel ball	Compound fracture of right patella. Shrapnel ball lodged in joint	—	Removal of the ball and resection of patella. Joint closed after treatment with formalin and glycerin. Skin suture
76	5.8.17	High-explosive shell	Small fragment penetrated left knee-joint just external to ligamentum patellæ	—	Removal of foreign body. Treatment with B.I.P.P. Capsule sutured. Wound closed
77	31.7.17	High-explosive shell	High-explosive fragment lodged in patella. Joint opened	—	Block excision of track and fragment. Joint washed out with saline and closed. Wound left open
78	31.7.17	High-explosive shell	Compound comminuted fracture of both condyles of left femur	—	Resection of joint and suture of operation wound
79	5.8.17	High-explosive shell	Wound outside and above right patella. Capsule torn. High-explosive fragment lodged in external condyle	*B. perfringens*	Casualty clearing station opened joint to inner side of patella and failed to find fragment. Joint washed out and treated with formalin and glycerin. Capsule sutured. Entrance wound on outside then explored. Foreign body not found
80	28.7.17	High-explosive shell	Penetrating wound into outer head of tibia, involving joint capsule	—	High-explosive fragment removed. Cavity treated with B.I.P.P. and pack applied
81	23.7.17	High-explosive shell	Entrance in popliteal space. Fragment injured articular branch of popliteal artery and entered joint, lying behind inner head of tibia	—	Clot evacuated. Artery ligatured. Foreign body not found. Wound treated with B.I.P.P. and left open
82	31.7.17	High-explosive shell	Entry over anterior aspect of left external condyle, exit at centre of popliteal space (complete fracture of condyle). (See *Fig.* 379)	Streptococci	Back splint

CASES—*continued.*

TIME FROM RECEIPT OF WOUND TO OPERATION	TREATMENT AT BASE	COMPLICATIONS	CONDITION ON EVACUATION	RESULT
—	Fragment removed from right biceps tendon. Wound left open	—	12.8.17. Temperature normal. Wounds granulating	—
Within twenty-four hours	Nil	—	20.8.17. No effusion. Temperature normal	—
Three hours	Nil	—	22.8.17. Temperature normal. Wound healed. No effusion	—
Eight hours	Nil	—	14.8.17. No effusion. Temperature normal. Stitches still in	—
Four hours	Nil	Nil	20.8.17. Temperature normal. Wound granulating	—
Thirty hours	Posterior ham-splint applied. Alinement adjusted	—	29.8.17. Has some bony union. Slight lateral displacement of shaft of femur outwards	—
Four days to operation at base	9.8.17. Removal of large fragment from external condyle. Capsule found to be torn the whole length of the suprapatellar pouch externally. Stitches from casualty clearing station wound removed, and long incision made in vastus externus. Bony cavity cleansed. B.I.P.P. applied. Wound left open. 14.8.17. Carrel-Dakin treatment. 3.9.17. Secondary suture, leaving track to bony cavity. 21.9.17. Resection of joint (see *Fig.* 377)	Mixed infection following *B. perfringens*	10.10.17. Fibrous union in good position	—
Fourteen hours	7.8.17. Repacked	—	10.8.17. No effusion. Temperature normal. Pack *in situ*	—
Twelve hours	Nil	—	8.8.17. No effusion. Temperature normal. High-explosive fragment *in situ*	—
Nine days	9.8.17. Removal of condyle for drainage 11.8.17. Resection of joint, necessitating a high section of shaft of femur	—	10.10.17. Evacuated in good position, with bony union	—

Continued on next page

PARTICULARS OF

CASE No.	DATE OF WOUND	MISSILE	NATURE OF INJURY	ORGANISMS FOUND	TREATMENT AT CASUALTY CLEARING STATION
83	15.8.17	Rifle bullet	Through-and-through wound with compound fracture of left patella (fissured)	Effusion sterile	Joint opened and washed with saline, followed by suture of capsule and skin closure
84	17.8.17	High-explosive shell	Multiple small wounds about right knee. One fragment in external head of tibia. One fragment in head of fibula. Also wounds of right thigh, right hand, right leg, and right foot	—	Removal of high-explosive fragment from thigh. Wounds about knee joint not operated on
85	23.8.17	High-explosive shell	Through-and-through wound of left suprapatellar pouch. Also entry wound to inner side of joint anteriorly. Small fragment lying behind shaft of femur. Fragment in right astragalus	—	Wounds excised and treated with B.I.P.P. ? suture of capsule. Skin cleansed
86	3.8.17	High-explosive shell	Entrance wound over inner head of right tibia. High-explosive fragment lodged in bone. Fissured fracture into joint. Multiple wounds elsewhere	Sterile effusion	Fragment removed. Brilliant-green pack and temporary suture
87	22.8.17	High-explosive shell	High-explosive fragment lodged in right tibia. Capsule penetrated. Compound fracture of superior maxilla	—	Wounds excised. Joint washed out. Capsule sutured. Fragments not removed (lying posteriorly in the bone: wound anterior)
88	23.8.17	High-explosive shell	Fragment of high-explosive shell, 7 × 2 mm., penetrated ligamentum patellæ and joint capsule, and lodged in inner head of tibia	—	Fragment removed. Ether injected. Brilliant-green pack to the bone, and temporary suture
89	17.8.17	Rifle bullet	Entrance wound above and behind head of left fibula. Exit above and anteriorly to inner head of tibia	Effusion sterile	Nil
90	23.8.17	High-explosive shell	Through-and-through wound of right lateral pouch	—	Joint washed out. Capsule sutured. Wounds excised and closed
91	21.8.17	High-explosive shell	Entrance wound to inner side of right knee-joint at level of joint. Fragment the size of a pea traversed the joint and lodged deep in the internal condyle	Sterile effusion	Back splint
92	21.8.17	High-explosive shell	Fragment traversed external head of left tibia and lay in joint	—	Removal of fragment. Joint washed out, and B.I.P.P. pack applied to cavity in tibia
93	24.8.17	High-explosive shell	*X*-rays show metallic dust in joint (?)	—	Casualty clearing station washed out joint and noted fissure at junction of internal condylar cartilage with bone. Capsule sutured, external wound treated with B.I.P.P. Closed

CASES—*continued.*

TIME FROM RECEIPT OF WOUND TO OPERATION	TREATMENT AT BASE	COMPLICATIONS	CONDITION ON EVACUATION	RESULT
Three days (lay out)	Thomas splint and extension applied	Nil	30.8.17. Wound healed. No effusion. Temperature normal	—
Ten days	Amputation of terminal phalanx right ring finger. High-explosive fragment removed from head of right tibia. External condyle is exposed. Wound left open. B.I.P.P. pack	—	1.10.17. Wounds granulating. Temperature normal. No effusion	—
—	30.8.17. High-explosive fragment removed from right ankle-joint. B.I.P.P. and suture	—	3.9.17. No effusion. Temperature normal	10.10.17. Walking fairly well
Seventeen hours	Brilliant-green pack changed for B.I.P.P. pack. Thomas splint and extension applied	—	14.9.17. No effusion. Temperature normal	—
Nineteen hours	Toilet of mouth and suture of lip	—	7.9.17. No effusion. Temperature normal	—
Eleven hours	Thomas splint and extension applied. Pack removed. Dry dressing	—	4.9.17. Temperature normal. No effusion. Wound granulating	—
—	—	Irregular pyrexia (P.U.O.)	2.10.17. Knee off splint. Movements good. Temperature now normal	—
Twelve hours	Thomas splint and extension	—	4.9.17. Temperature normal. No effusion. Stitches still in	—
—	Thomas splint and extension	—	4.9.17. Temperature normal. Effusion diminished	—
Twelve hours	Pack removed	Nil	4.9.17. Suture line healed. Wound in tibia granulated. Temperature normal	—
Twelve hours	Thomas splint and extension applied	—	4.9.17. No effusion. Temperature normal. Stitches *in situ*	10.10.17. Walking, but knee still stiff. Under treatment

Continued on next page

PARTICULARS OF

Case No.	Date of Wound	Missile	Nature of Injury	Organisms Found	Treatment at Casualty Clearing Station
94	24.8.17	High-explosive shell	Through-and-through wound of right knee-joint. Entrance wound internal to inferior margin of patella. Exit behind head of fibula	—	Aspiration of blood and synovial fluid
95	27.8.17	High-explosive shell	Wound over internal condyle of right knee-joint. Capsule torn by fragment, which lodged in internal condyle, outside the capsule	*Staphylococcus aureus*	Removal of fragment. Capsule sutured. Wound closed, with drain down to fracture
96	1.9.17	High-explosive shell	Fragment entered left knee-joint, and lay loose in region of internal condyle, tearing ligamentum patellæ as it entered. High-explosive fragment lodged in calcaneo-astragalar articulation, fracturing the astragalus. Entrance and exit wounds of left buttock	—	Fragment removed. Lavage of joint with eusol. Suture of capsule, and repair of ligamentum patellæ. Wound closed
97	30.8.17	High-explosive shell	Multiple wounds about right knee-joint, penetrating capsule. No bony lesion. No foreign body retained	—	Excision of wounds. Lavage of joint. Suture of capsule. B.I.P.P. Wound left open
98	5.9.17	High-explosive shell	Large laceration of vastus externus, tearing the capsule in the region of the right suprapatellar pouch	—	Excision of wound. Joint irrigation with Dakin's solution. Capsule sutured. B.I.P.P. and pack into wound. Temporary suture over pack
99	9.9.17	High-explosive shell	Lacerated wound of left thigh, with tear in capsule of left suprapatellar pouch. Many fragments of bone (from a comrade) implanted	—	Excision of wound. Removal of alien bone. Joint lavage with Dakin's solution. Capsule sutured. B.I.P.P. Closure of wound
100	5.9.17	High-explosive shell	Penetration of right knee-joint, with comminution of patella, and with a fragment lodging in intercondylar notch. Compound fracture of right tibia, lower third	—	Resection of patella. Removal of foreign body. Toilet of bony cavity between the condyles. B.I.P.P. applied and capsule sutured. Skin closed as far as possible. B.I.P.P. applied in right tibia

CASES—*continued.*

TIME FROM RECEIPT OF WOUND TO OPERATION	TREATMENT AT BASE	COMPLICATIONS	CONDITION ON EVACUATION	RESULT
Two days	Thomas splint and extension applied	Nil	6.9.17. No effusion. Temperature normal	—
Two days	Thomas splint and extension. Drain removed. 13.9.17. Resection of joint	—	11.10.17. Fibrous union in good position	—
Fourteen hours	6.9.17. Large high-explosive fragment removed from left ankle-joint	—	1.10.17. Temperature normal. No effusion	—
Twenty-hours	Splint and extension	Compound fracture of left patella	27.9.17. Temperature normal. No effusion in the joint	—
Twelve hours	Stitches removed. Pack changed	Division of right ulnar artery. Superficial wounds of left leg and forehead	22.9.17. No effusion. Temperature normal	—
Within twenty-four hours	Splint and extension	Wounds of right thigh and left forearm	21.9.17. No effusion. Temperature normal	—
Eighteen hours	Splint and extension	—	2.10.17. Wound granulating. Temperature normal	—

A CASE OF FASCIAL GRAFTING FOR THE REPAIR OF TRAUMATIC STRICTURE OF THE URETHRA.

By Staff Surgeon R. J. WILLAN, R.N.V.R.

On July 28, 1911, Albert L., age 32, fractured his pelvis through being crushed between a moving tub and the wall while working down a coal mine. He bled from the urethra and had retention of urine. He was removed at once to a hospital, where his bladder was immediately opened, both perineally and suprapubically, in order to relieve the acute retention. He states that during the next four months he had several operations, " as the passage could not be kept open." Apparently these 'operations' consisted of passing dilating bougies under a general anæsthetic.

Despite frequent attempts, no dilating instrument had been passed through the stricture for the fourteen months previous to the patient coming under my care. For the last six months of this period he had increasing difficulty in getting his urine away ; he had to strain very hard at micturition, to such a degree that he had incontinence of fæces ; moreover he was endeavouring to pass urine every half-hour night and day. The stream was getting smaller, until it had become a forceless dribble, and several times he had had temporary retention of urine ; but relief had always been gained by the local application of hot flannels.

On Jan. 7, 1913, he was admitted to the Royal Victoria Infirmary, Newcastle-upon-Tyne, with acute retention of urine. Before he left his home the doctor had informed him that the only possible relief he could look forward to was a permanent suprapubic fistula. In appearance he was thin and anæmic. There were healed scars in both the perineal and suprapubic areas. The urethroscope demonstrated a stricture just behind the compressor urethræ muscle ; the opening of the stricture could not be defined. A rectal examination demonstrated a hard mass of cicatricial tissue at the normal situation of the prostate ; the gland itself not being recognizable with the examining finger owing to the inflammatory tissue. The x rays showed an old united fracture of both pubic bones.

Emergency Operation.—To relieve the acute retention, an endeavour was made to insinuate the fine gum-elastic 'guide' of a urethrotome through the stricture preliminary to dividing it by internal urethrotomy ; this was not successful. The patient was therefore placed in the lithotomy position, and the urethra was opened in the perineum on a Wheelhouse staff. Despite a prolonged search, the opening of the stricture could not be recognized. I then opened the bladder suprapubically, and the area of the stricture was examined by means of a metal sound passed by retrograde catheterization into the prostatic urethra. At the same time a finger was inserted into the rectum.

It was ascertained that the ends of the torn urethra were separated by half an inch of scar tissue; also that the prostatic end of the canal was deflected, and fixed in dense cicatricial tissue in a position well to the right of the middle line and downwards towards the free margin of the triangular ligament (*Figs.* 380, 381, 382). The bladder was drained suprapubically by a tube; the urine was highly offensive, owing to a purulent cystitis.

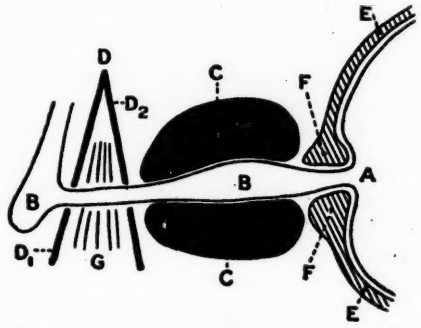


FIG. 380.—Showing the normal relations of the parts.

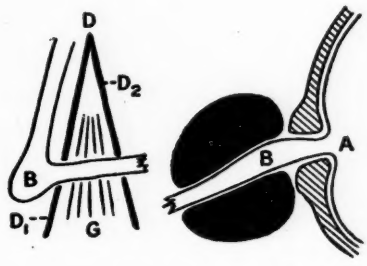


FIG. 382.—Showing the downward displacement of the proximal fragment

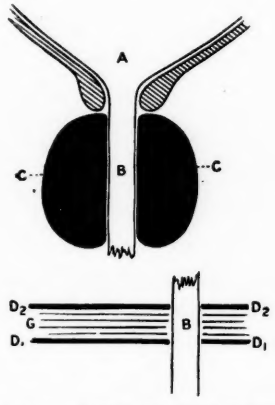


FIG. 381.—Showing the lateral separation of the torn ends.

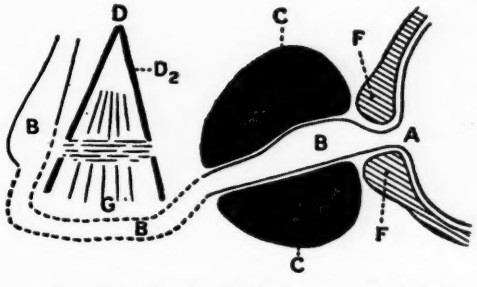


FIG. 383.—Showing the fascial graft (in dotted outline) uniting the penile and prostatic portions of the urethra. The membranous portion has been destroyed, and is replaced by fibrous tissue.

FIGS. 380–383.—DIAGRAMS OF THE PROSTATIC AND MEMBRANOUS URETHRA, ETC., ILLUSTRATING THE NORMAL RELATIONS OF THE PARTS AND THE CONDITIONS IN THE PRESENT CASE.

A, Bladder. B, Urethra. C, Prostate gland. D, Triangular ligament. D_1 Superficial layer of ligament; D_2, Deep layer. E, Bladder-wall muscle. F, Internal sphincter. G, Compressor urethræ.

First Plastic Operation.—Some time before, I had the advantage of watching Professor Morison do a successful plastic operation upon the penile urethra of a lad; the patient had a stricture about two inches behind the external meatus, and a piece of tensor fasciæ femoris was used for the plastic.

On Jan. 23, I performed a plastic operation upon my patient in the following manner. Placing him in the lithotomy posture, the separated ends of the torn urethra were first defined. Owing to the inaccessibility of the anterior torn end, where it emerged at the *posterior layer* of the triangular

ligament, the urethra was completely divided transversely immediately in front of the *superficial layer* of this ligament. The epithelial lining of the membranous portion of the urethra was completely destroyed by swabbing it with acidum carbolicum liquefactum. The cicatricial tissue in front of the proximal end of the torn urethra was dissected away. My work now was to fill in the gap between the two ends of the urethra, a gap larger than ever owing to my destruction of the membranous portion. In other words, I had to provide a new length measuring $1\frac{1}{4}$ inches, which, moreover, must be left with a permanent lining of epithelium if a cure was to be effected. In filling up the gap, the new part of the urethra had either to tunnel the triangular ligament or be carried round its free margin. The latter alternative was chosen, because it was the easiest.

I obtained a length (about $1\frac{1}{2}$ inches) of the patient's left internal saphenous vein at its upper part, together with an oblong (2 inches by 1 inch) from his tensor fasciæ femoris ; both of these were handled as little as possible, and were kept immersed in hot saline solution until they were actually required. This fascia (with its glistening muscle surface towards the lumen) was first sutured into position with interrupted catgut sutures ; these were placed close to the cut margins of the urethra in front and behind, also laterally ; no attempt was made to approximate the lateral margins of the fascia, that is, to complete the 'floor.' The vein was slit up as it lay in the saline solution. Unfortunately the lumen was of small calibre ; but its extremities were sutured to the cut ends of the urethra by interrupted catgut sutures, while the sides of the cut vessel were sutured to the portion of tensor fasciæ femoris which enveloped it. The new portion of the urethra therefore consisted of a piece of vein, around the outer surface of which a fascial flap was wrapped, and the 'floor' remained quite open. To prevent any adhesion of the surfaces, and to provide a splint, a rolled-up piece of indiarubber tissue was laid along the *whole* length of the urethra. The suprapubic drainage tube was retained.

At the end of seven days the rubber tissue drain was removed. Three days later I passed a No. 15 (English gauge) metal bougie. When the point of the instrument was passing the site of the plastic operation, I felt something tear, although the instrument passed onwards into the bladder quite easily. There is no doubt that the tearing, hardly perceptible though the sensation was, was sufficient to dislodge completely the anterior detachment of the graft. The bougie was passed again a few days later, but the bladder was reached with difficulty. A few days after this the bladder could not be reached at all, even under a general anæsthetic.

Second Plastic Operation, Feb. 5.—As I attributed the failure of the first plastic operation largely to the small calibre of the vein employed, I resolved to use a fascial graft only at the next attempt. Having obtained an oblong of tensor fasciæ femoris, similar in size and shape to the one used at the previous operation, this was fixed into the gap by interrupted catgut sutures to either end of the urethra ; the graft was also sutured laterally to the surrounding tissues, although the 'floor' lay quite open. As in the previous operation, the glistening medial surface of the graft was turned towards the lumen of the urethra. It lay in the place occupied before by the length of

saphenous vein, that is, it was sutured directly to the ends of the urethra. The relation of the new portion of the canal to the base of the triangular ligament is shown in *Fig.* 383.

The posterior end of the urethra was slit along the floor into the prostate gland. A short length of rubber tubing was laid in the prostatic urethra, and brought out through the perineal wound behind the level of the urethral graft; this tube had its lumen occluded with a ligature, and the inner end did *not* enter the bladder. To the middle of the upper surface of this rubber tube was sutured a piece of indiarubber tissue drain; this was brought out through the external meatus. The posterior part of the urethra, therefore, was occupied by a rubber tube, while the rest of the canal was occupied by rubber tissue. A small piece of iodoform gauze was placed at the areas of suture both in front and behind. The services of the suprapubic drainage tube were still employed.

The perineal tube and the tissue drain were left undisturbed for ten days; each day the perineum was carefully irrigated with saline solution to wash away any pus which had accumulated, and at the end of the time mentioned the perineal drains were removed. At the end of fourteen days a No. 16 (English gauge) metal bougie was easily passed.

The suprapubic drainage tube was kept in until April 5, by which time it was quite certain that the bougie could be passed with perfect ease. By the time that the patient left hospital, nine days later, the suprapubic sinus was soundly healed, and he was passing a full-sized stream during micturition.

After-History.—For a week or two after the suprapubic wound had healed, the patient had a slight incontinence of urine. I saw him on June 26,—i.e., twenty weeks after operation—when he had full control of micturition, and I passed a No. 14 bougie with ease.

On Aug. 7, 1914, he came to see me by request, when he looked well and fat. He stated that he had some urgency of micturition, and that if he could not arrange to pass his water immediately the desire was felt, his urine came away. However, there was no incontinence of urine, night or day. He had to get up once during the night to micturate, while during the day he could carry on for three hours. The stream was a single, full-sized one. A No. 16 (English) catheter was passed without any difficulty. Wishing to know the appearance of the graft, I examined him with the urethroscope. It showed, 5 inches from the external meatus, the lumen rather narrower than the portion in front; while instead of the straw colour of a normal part of the urethra, the new portion was white in colour like scar tissue; unlike scar tissue, however, this surface had a 'sheen' on it, due to a covering of epithelium.

I again saw the patient in February, 1916—that is, over three years after the operation. He was then in good health, and a No. 16 (English) bougie was passed without obstruction. He still had some urgency of micturition.

The urgency is a sequel to his long-standing cystitis. The infection was probably self-induced, for he had been using a dilating bougie upon himself ever since the time of the original accident. When I last saw him he was continuing this practice. I tried to persuade him to give up the habit, as he was really cured, but he could not forget his previous sufferings when unable

to micturate. He stated that it gave him great mental comfort to be able to satisfy himself periodically that a large bougie passed easily.

In a letter from him dated Oct. 14, 1917, patient informs me that he is in good health, but still passes the bougie from time to time.

Remarks.—The first plastic operation failed primarily owing to the vein being of too small a size; secondarily, to my passing a bougie too soon afterwards, for the point of the bougie encountered the vein, which acted as an obstacle and tore away the anterior attachments as mentioned.

A difficulty to overcome was to prevent the surface of the tensor fasciæ femoris from adhering, and the soft, pliable, rubber tissue drain was used as being less likely than gauze to destroy the fascial graft.

The fascial graft probably only acts as a scaffolding for the urethral epithelium to grow along. I consider that this has certainly happened, for the urethroscope shows that there is a sheen on the walls of the lumen at this new portion of the urethra, which can *only* be due to epithelium. The ability to pass a large-sized bougie so easily is confirmatory evidence; for if the walls of the 'gap' were lined with cicatricial tissue instead of epithelium, it would very quickly close up and become an impassable stricture. Professor Morison suggests that the epithelium referred to may possibly originate from the surface of the graft. I therefore asked Professor Stuart McDonald if he would examine sections of tensor fasciæ femoris with a view to ascertaining if there are any endothelial cells upon the medial surface of this fascia. He has very kindly done so; sections cut from two cases were examined, and he informs me that he cannot see any trace of endothelial cells. He suggests that a number of cases should be examined, though he would still expect the search for endothelium to be negative.

The patient is of course entirely dependent upon the bladder sphincter (at the internal meatus) for continence of urine, because his compressor urethræ muscle cannot now play any part in this function. He was warned of the risk of incontinence of urine before the plastic operation was embarked upon, but he promptly expressed his willingness to risk anything rather than continue his previous miserable existence of constant endeavouring to micturate; nor could he tolerate the alternative of having a permanent suprapubic fistula. Fortunately, with the exception of some urgency, he has full control.

A NEW OPERATION FOR THE SUBSTITUTION OF A THUMB.

By Brevet-Major J. L. JOYCE, R.A.M.C. (T.)

An operation has been devised to substitute a ring finger of the opposite hand for a thumb lost as a result of injury or disease. The well-known method of employing a pedunculated flap is used in this operation, but the idea of substituting a finger for a lost thumb of the opposite hand is believed to be a new and useful advance in surgery.

The patient for whom this operation was devised, and on whom it was afterwards practised, is an electrical engineer who lost the whole of his right

Fig. 384.—The right hand before operation.

Fig. 385.—*X*-ray photograph of the right hand before operation.

thumb, including its metacarpal bone, as the result of a gunshot wound received in action on the Somme in July, 1916 (*Figs.* 384, 385). The operation is described under the following headings :—

1. Preparation of the bed for the reception of the new metacarpal bone, and exposure of the proximal end of the divided tendons of the old thumb.

2. Dislocation of the ring finger of the opposite hand at the metacarpo-phalangeal joint, involving division of the soft tissues at the base of the radial

side of the proximal phalanx, division of the extensor and flexor tendons, and the preservation of a nutritive flap on the ulnar side of the finger.

3. Fixation of the new metacarpal bone (proximal phalanx of ring finger) in its bed, union of tendons and nerve, suture of incisions, and fixation of the hands in apposition.

4. Division of nutritive flap—two months later than 1, 2, and 3.

1. An incision is made along the radial border of the hand, beginning at a point which corresponds with the horizontal level of the centre of the web between the index finger and the thumb of the sound hand, and rather nearer the dorsum than the palm. When the wrist is reached, the incision is carried along the radial border of the forearm for a distance of $1\frac{1}{2}$ to 2 inches. The incision on the side of the hand is deepened sufficiently to accommodate the new metacarpal bone, care being taken not to cut across muscle fibres. In the patient on whom the operation was performed, a plane of fibrous tissue was found apparently filling up the space left by removal of the metacarpal bone, and in this the bed was made. The articular surface of the trapezium is exposed. The skin and superficial and deep fascia on either side of the incision along the radial border of the wrist are reflected, the tendons of the extensores secundi internodii pollicis, primi internodii pollicis, ossis metacarpi pollicis, flexor longus pollicis, and flexor carpi radialis are defined, and one of the dorsal cutaneous branches of the radial nerves is found and divided.

2. An inverted V-shaped incision is made on the radial side of the ring finger, the apex of the incision being placed midway between the dorsal and palmar aspects of the finger at the level of the proximal inter-phalangeal joint. The triangular piece of skin marked out by the incision is then reflected upwards. The limbs of the incision are carried obliquely backwards and forwards on to the dorsum and palm of the hand, and are deepened in order to expose the extensor and flexor tendons. These are divided at the extremity of the incisions, and the proximal ends prevented from retracting by suturing them to the periosteum and soft tissues covering the metacarpal bone. The soft tissues are now divided at the base of the proximal phalanx on its radial side down to the periosteum. The digital vessels on this side of the finger are tied, and the distal end of the collateral branch of the median nerve is sought for and identified. The extensor and flexor tendons are dissected up in a distal direction, exposing the base of the proximal phalanx, and a hole is drilled through the base of the bone and threaded with a stout catgut suture. The finger is now dislocated from the metacarpal bone by cutting through the ligaments of the metacarpo-phalangeal joint. The soft tissues on the ulnar side of the proximal phalanx are raised for a short distance from the periosteum, working from the deep aspect, taking care not to injure the digital vessels.

The triangular flap of skin is now turned down to cover over the head of the metacarpal bone, and the incisions on the dorsum and palm of the hand are sutured with fine catgut stitches. The proximal end of the extensor tendon is pulled over to the palmar aspect of the hand, and the ring finger is then ready for grafting into its new position.

3. The two hands are apposed in a manner which is sufficiently indicated in the accompanying photographs (*Figs.* 386, 387). This stage of the operation is now completed as follows :—

a. The flexor tendons of the finger are joined to the long flexor of the thumb, if this has been found, or to the flexor carpi radialis if more convenient.

b. The proximal phalanx is anchored in its position by stitching the catgut suture threaded through its base to the scar tissue covering the articular surface of the trapezium.

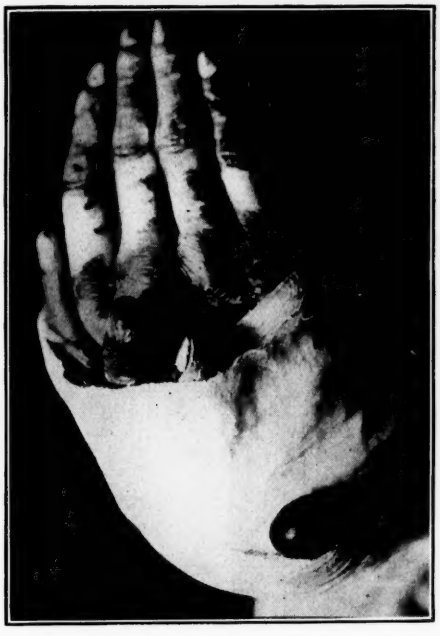


FIG. 386.—The two hands apposed in plaster-of-Paris.

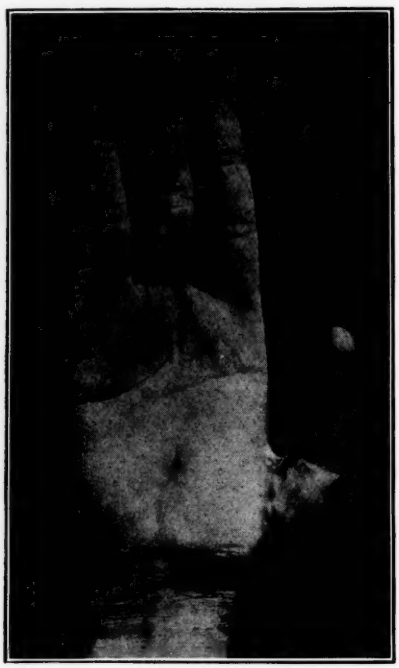
FIG. 387.—The two hands grown together after removal of the plaster.

c. The extensor ossis metacarpi pollicis is stitched to the periosteum at the base of the proximal phalanx (new metacarpal bone).

d. The tendons of the extensores secundi and primi internodii pollicis are united and joined to the extensor tendon of the finger (new thumb).

e. The radial cutaneous nerve exposed in the first stage of the operation is sutured to the collateral branch of the median nerve of the ring finger.

f. The skin incisions are sutured. The incision on the radial border of the wrist is sutured in a distal direction to cover the base of the new metacarpal bone and the tendon unions. The dorsal and palmar edges of the incision on the radial border of the hand are sutured to the dorsal and palmar edges of the skin bordering the triangular raw area on the radial border of the ring finger (new thumb). Fine interrupted catgut sutures are used throughout for the skin stitches.



FIGS. 388, 389.—The right hand after the operation was completed.

FIG. 390.—*X*-ray photograph of the right hand after the operation was completed.

The hands are then fixed in the apposed position by plaster-of-Paris, which is left undisturbed for four weeks, and is then removed.

4. The final stage in the operation consists in dividing the nutritive flap, separation of the hands, ligature of the proximal ends of the ulnar digital vessels of the finger which has been removed, and closing the raw areas which remain. *Figs.* 388, 389, 390 show the hand after completion of the operation.

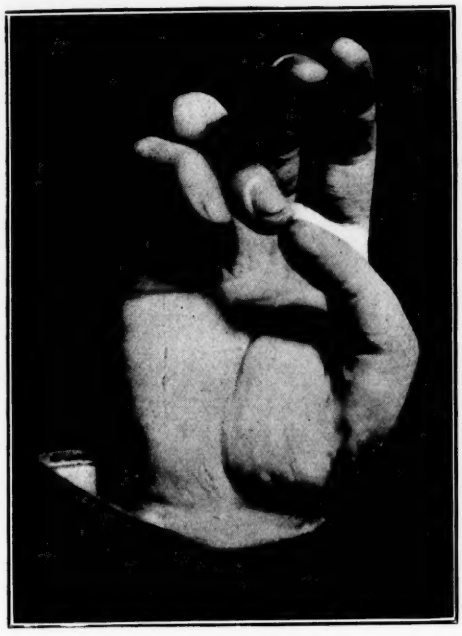


Fig. 391.

The time for completing the operation depends on the establishment of a sufficient collateral circulation between the vessels of the new thumb and its hand. This can be easily tested by compressing the blood from all the fingers (including the late ring finger) and the hand of the member which has provided the new thumb, and stopping the arterial blood-supply. All the fingers will then remain cold and blanched, with the exception of the late ring finger, which will retain its warmth and colour if an efficient new circulation has been established.

In the case of the patient on whom this operation was performed, the first three stages were carried out on Aug. 11, 1917. The plaster was removed on Sept. 14. The hands were separated on Oct. 13.

In performing the operation, every step was carried out as described, with two exceptions:—

a. The flexor tendons of the ring finger were not united to the flexor longus pollicis or the flexor carpi radialis, but were left unattached in the bed of the thenar muscles.

Fig. 392.

b. No nerve union was made between the digital nerves of the ring finger and the cutaneous nerves of the opposite hand.

These steps were omitted as it seemed desirable that too much should not be attempted at once. The first omission matters, for while the patient

has now acquired active voluntary movements of the extensors, he has no power of flexing the two terminal phalanges of his thumb.

The omission of the nerve union is thought to be of little importance, as the patient already has a considerable return of protopathic sensation on the ulnar side of his new thumb (radial border of the late ring finger).

The accompanying photographs (*Figs.* 391, 392, 393, 394) are a sufficient commentary on the usefulness of the patient's new thumb, and it is enough to add that he now feels himself able to follow his profession, and can write a legible letter with his right hand, holding his pen in the usual manner.

FIG. 393.

FIG. 394.

FIGS. 391–394 illustrate the usefulness of the new thumb.

The whole of this patient's right thumb has been replaced by the ring finger of the left hand, and it is considered that by suitable modifications in the details of the operation any less part of a thumb can be similarly replaced by substituting for it a part of a finger of the opposite hand.

My thanks are due to Mr. A. Rhodes, who not only gave me his assistance at the operation, but has prepared the photographs which illustrate this paper, and to my Commanding Officer, Brevet-Colonel W. J. Maurice, for his advice and encouragement, and for his permission to publish the case.

SHORT NOTES OF RARE OR OBSCURE CASES.

CASE OF TRAUMATIC ANEURYSM OF THE RADIAL ARTERY.

By Temporary Surgeon C. P. G. WAKELY, R.N.

Traumatic aneurysm of the radial artery is not very common, no doubt owing to the fact that the vessel is often completely cut across, or that, in shell wounds, a portion of the vessel is often blown away together with the surrounding muscles. Mr. Rutherford Morison[1] describes a case in which he excised the sac of the aneurysm, and Sir George Makins,[2] in his article

Fig. 395.—Antero-posterior view.

Fig. 396.—Lateral view.

Skiagrams of lower part of forearm, showing the piece of steel lying about two inches above the wrist.

"Vascular Lesions in War," reports one case of traumatic aneurysm of the radial artery in a series of 111 cases of traumatic and arterio-venous aneurysm. Sir George Makins considers that traumatic aneurysms of the radial and ulnar arteries are rare, "on account of their small size, and the frequency with which they suffer complete division."

The case I am about to describe occurred in a discharged Belgian soldier (H. S.), age 26. He was working in a blacksmith's shop in Camberwell in

March, 1915, when a small piece of hot steel struck his left forearm on its outer aspect about 2½ inches above the wrist; it caused him some pain for the moment, but he soon forgot all about it. About three weeks afterwards he attended King's College Hospital because a small pulsating swelling had appeared above the wrist on the antero-external surface of the forearm. This was thought to be an aneurysm of the radial artery. The patient was *x*-rayed, and a small foreign body was seen lying close to the inner surface of the radius about 2 inches from the lower end of the bone (*Figs.* 395, 396). The patient was kept under observation for a week, the swelling increasing during that time to the size of a pigeon's egg.

An operation was performed on April 5. A vertical incision was made over the tumour, and the sac excised, hæmorrhage being easily controlled by

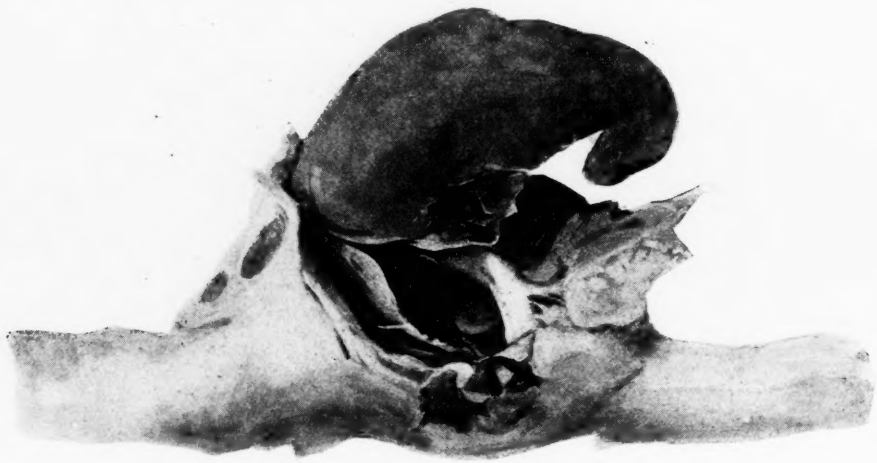


FIG. 397.—Aneurysmal sac opened to show laminated clot.

compressing the brachial artery against the tendon of the biceps in the antecubital fossa. The proximal and distal portions of the artery were ligatured. The piece of steel was found to be sticking into the side of the aneurysmal sac. The wound healed rapidly, and the collateral circulation was perfect. *Fig.* 397 shows the dissected sac.

Radical treatment was indicated in this case, because the aneurysm was rapidly increasing in size and any traumatism might have caused its rupture, either externally or into the subcutaneous tissue of the forearm. In either of these conditions operation would have been needed at once, would have been much more difficult, and suppuration might have taken place.

Excision of the aneurysmal sac is recommended by Regnault and Bourrat-Laconture[3] in cases of aneurysm of the small arteries of the extremities. They report a case of aneurysm of the superficial palmar arch treated by ligature of the artery at each end of the sac.

REFERENCES.

[1] BRIT. JOUR. SURG, 1914, i, 724. [2] *Ibid.*, 1916, iii, 391. [3] *Rev. de Chir.*, 1913, 337.

A CASE OF PARTIAL SEPARATION OF THE CALCANEAL EPIPHYSIS.

By C. HAMILTON WHITEFORD, Plymouth.

A boy, age 14, while paddling in the sea, slipped, and brought the bare heel of the left foot into hard contact with a rock.

7th Day.—Seen for the first time. The posterior and plantar surfaces of the heel were tender. There was slight lateral swelling, with no discoloration. The *x* rays showed a partial separation of the calcaneal epiphysis (*Fig.* 398). The heel was bandaged, with the foot in plantar flexion. Weight-bearing on the foot was prohibited, and gentle massage was applied daily to the parts surrounding the tender area.

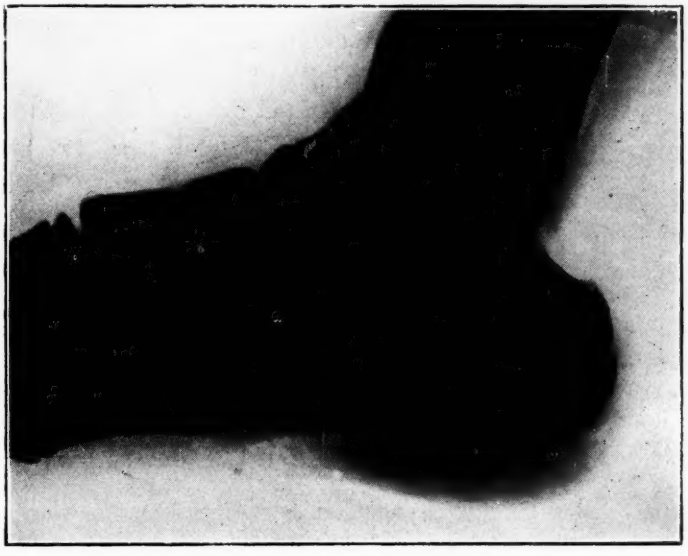


Fig. 398.—Skiagram showing partial separation of the epiphysis of the os calcis.

29th Day.—The tenderness was unaltered, the patient having made repeated attempts to bear weight on the foot. The limb was fixed in a poroplastic case extending from the toes to the middle of the thigh. The case held the foot in plantar flexion, with forty degrees of flexion at the knee.

47th Day.—Tenderness had nearly disappeared. Gentle walking was permitted, the boot having a raised heel.

68th Day.—An ordinary boot was worn.

15th Week after the injury.—Walking was normal. There was no tenderness. Dorsiflexion and plantar flexion were perfect. Viewed from the sole, there was slight lateral thickening in comparison with the uninjured side.

Comments.—Traumatic separation of the calcaneal epiphysis appears to be rare. Little or no information on the subject is given in the text-books. Normally the epiphysis unites with the body of the bone soon after puberty. It will be of interest to note what effect the injury may produce on the development of the heel.

A CASE OF GUNSHOT WOUND OF THE LIVER, WHERE THE MISSILE, ENTERING THE CIRCULATION THROUGH THE HEPATIC VEIN, WAS FOUND LODGED IN THE RIGHT VENTRICLE OF THE HEART.

By Captain J. E. McCARTNEY, R.A.M.C.,
and Captain HAMILTON DRUMMOND, R.A.M.C.

Several instances have recently been described of 'wandering' shrapnel balls and shell fragments within the vascular system; the present case deals with a wandering fragment of shell.

The missile, a triangular piece of shell about one inch in length, entered the thorax between the seventh and eighth ribs on the right side, in the

Fig. 399.—Right side of heart laid open to show missile lying embedded in the ventricle.

mid-axillary line. It then opened the right pleural cavity without touching the lung, pierced the diaphragm, and entered the liver. The fragment traversed the right lobe, and passed into a large branch of the right hepatic vein, in this way gaining access to the inferior vena cava. The missile was subsequently found at autopsy lying between the columnæ carneæ of the right

ventricle of the heart, its apex being surrounded by firm white clot which was not of recent origin (*Figs.* 399 and 400).

The patient had, in addition, other serious wounds, and survived his injuries for thirty-six hours. The presence of the missile in the heart was not suspected during life.

At the autopsy, the liver showed a large lacerated wound of the right lobe, but no exit wound was visible. When the track of the missile was fol-

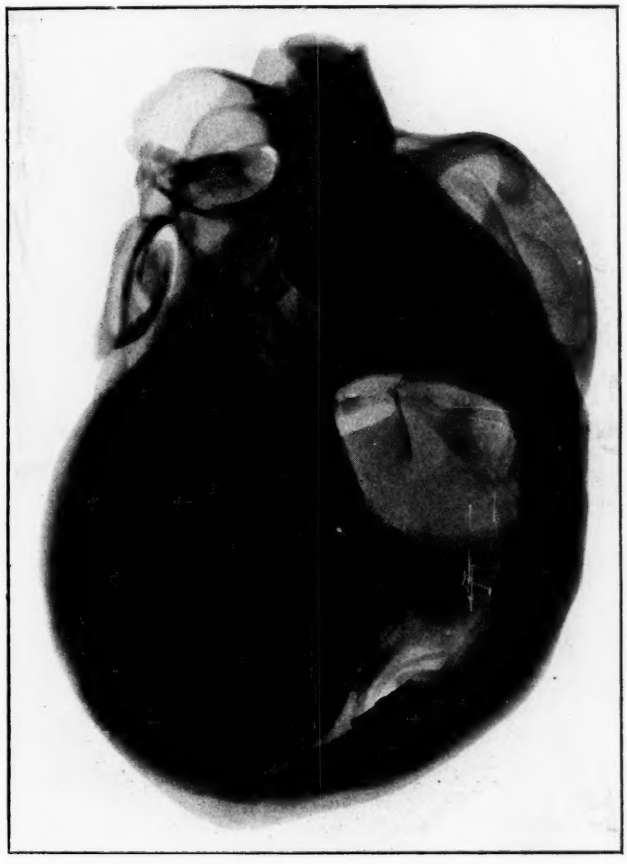


FIG. 400.—*X*-ray photograph of heart taken from behind, so that missile appears on right side of photograph.

lowed up, it became evident how the shell fragment had gained access to the circulation. The wall of the hepatic vein showed a long ragged tear, about two inches in length, where the missile had entered obliquely (*Fig.* 401).

From the fact that the shell fragment was very rough and irregular, and that there was neither damage to the intima nor adherent clot in the inferior vena cava, it seemed probable that the missile, on entering the vena cava, was very soon carried up in the blood stream to the right auricle, from whence it would naturally drop into the ventricle.

The fatal issue in this case was probably due to a combination of hæmorrhage from the hepatic wound, and shock. It could not be attributed to the presence of the missile in the heart.

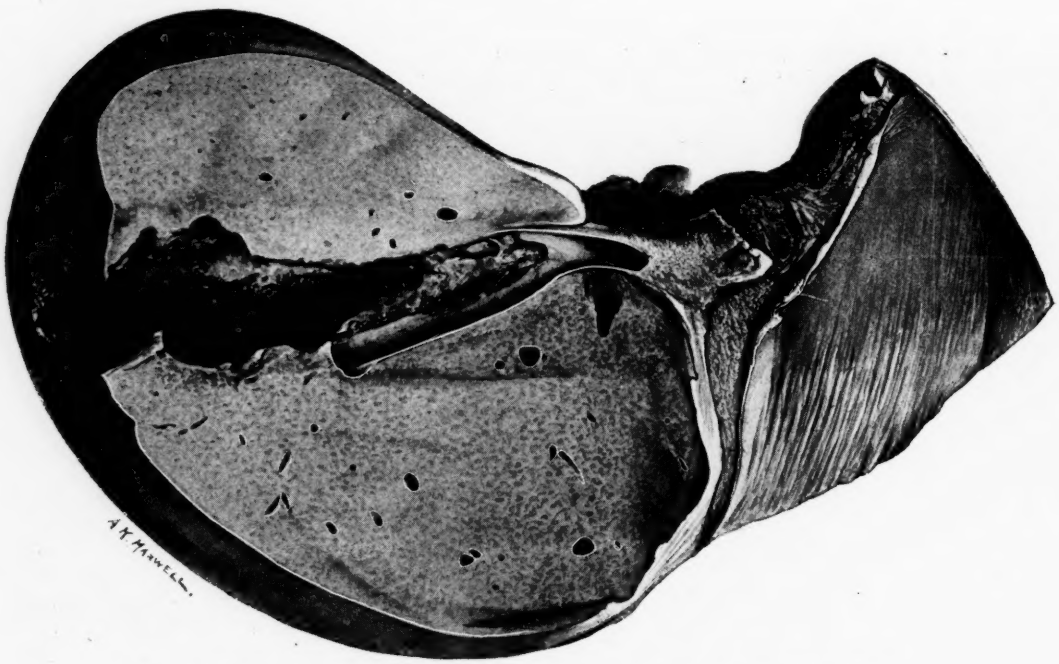


FIG. 401.—Section of liver showing the ragged wound of entry of missile into right hepatic vein.

We are indebted to the Medical Research Committee for permission to reproduce the two drawings by Sergeant A. K. Maxwell, R.A.M.C.

AN UNUSUAL CASE OF RENAL CALCULUS.

BY F. C. PYBUS, NEWCASTLE-ON-TYNE.

Although calculi, wherever situated, often tend to assume the shape of the cavity in which they are contained, it is rare for them to form a complete cast of the interior of their cavity. The renal calculus here described formed a perfect cast of the interior of the pelvis and calices of the kidney and the upper portion of the ureter.

Private R. A. C., age 36, was admitted to the 1st Northern General Hospital on Aug. 31, 1916, with pains in the left loin and back. He showed two small phosphatic calculi which he had passed recently, and stated that he had passed similar ones for years. It was found he had a temperature of 101°, that the urine was alkaline and contained pus, and that there was a large tender swelling in the left loin. A diagnosis was made of perinephritic abscess, due probably to calculous pyonephrosis.

X-ray examination showed a shadow in the region of the left kidney,

corresponding to the calices and pelvis, and to the upper part of the ureter (*Fig.* 402). Major Arnison reported that this latter region was occupied by a large calculus, or was filled with dense pus.

On Sept. 2, an oblique incision was made in the left loin, and about one pint of stinking pus evacuated. The cavity was drained by a rubber tube. The pus contained a pure culture of the *Streptococcus longus*. A few days later a second *x*-ray examination revealed the shadow in the same situation.

On Sept. 27, the wound having closed down to a small sinus with very little discharge, a second operation was undertaken. The

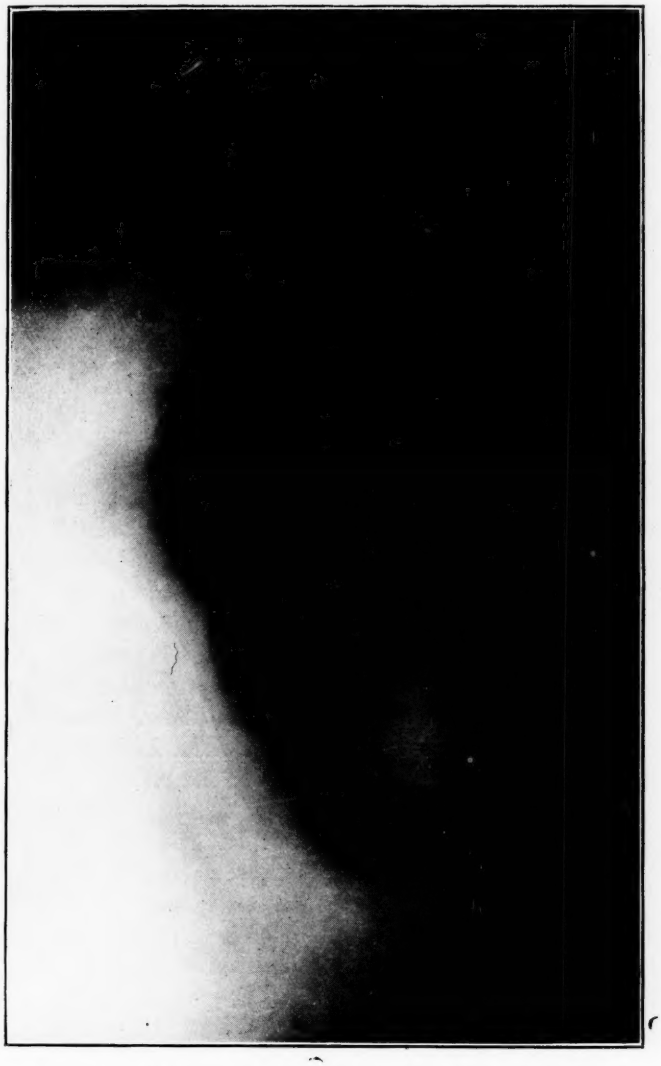


FIG. 402.—Skiagram of left loin, showing shadow of renal calculus.

FIG. 403.—Photograph of stone after removal. (× ¾.)

original wound was enlarged, and the kidney found, containing a large stone in its pelvis. The kidney was separated, and drawn up to the margin of the wound. The stone seemed too large to be removed by opening the pelvis, so the kidney was incised along its convex border. The renal tissue was not greatly thinned; the stone was therefore disengaged from the calices, and withdrawn without difficulty. Two small isolated fragments, seen in the

skiagram, were removed from adjoining calices. A probe was passed down the ureter, which was patent. A tube was inserted into the pelvis of the kidney through the cortex, and the remainder of the wound in the kidney was closed with catgut sutures. The incision in the loin was then closed, a small drain being left in the perirenal space.

On Nov. 8 the patient was discharged to an auxiliary hospital, the wound being healed. He was much improved in general condition, the urine containing only a trace of pus. On two occasions since the operation he passed small calculi per urethram. No further calculi could be detected in either kidney or bladder.

Fig. 403 shows the stone, three-quarters of the actual scale, which weighs just over $1\frac{1}{2}$ ounces, and, even when dried, has still a trace of smell. It appears to be composed of phosphates, and forms a complete cast of the pelvis and calices and the upper $1\frac{1}{4}$ inches of the ureter.

HÆMATEMESIS AND MELÆNA CAUSED BY A PIECE OF METAL FROM THE ŒSOPHAGUS PERFORATING THE AORTA.

By NORMAN H. BEAL, London, Canada.

On May 8, 1917, the writer was called in consultation by Dr. C. W. Crawford to see a woman, age 60, suffering from severe shock following hæmatemesis. The history and progress of the case were briefly as follows :—

The patient, a trained nurse, was found during the previous afternoon lying on the floor in a pool of blood. Twice during the next eighteen hours she vomited a quantity of bright red blood, which showed no characters to indicate that it had come from the lungs. The patient was placed under morphia, all nourishment by mouth was interdicted, and rectal salines with 5 per cent glucose were administered. The source of the hæmorrhage was thought to be probably from the stomach or duodenum. On the morning of May 9 the patient seemed somewhat improved; she had not vomited for twenty hours, but had passed two large stools of bloody material. She now complained of severe precordial pain, radiating down the left arm, and a constant desire to vomit. No history of previous trouble could be elicited, and fearing that in the absence of a definite history laparotomy would fail to discover the source of the hæmorrhage, the writer advised against operation. In this Dr. H. A. McCallum, who was called in consultation, agreed. Efforts were made to procure a donor for transfusion in case of further hæmorrhage. At 6.0 p.m. another large movement of blood was passed per bowel, accompanied by hæmatemesis. The patient became pale, and showed the clinical signs of a large loss of blood. As a suitable donor had not been obtained, an intravenous saline was given; but the patient failed to respond, and died at 7.0 p.m., fifty-two hours after the first hæmatemesis.

Post-mortem Examination.—Permission for an autopsy was granted, which was performed by Dr. F. W. Luney, of the Institute of Public Health. The following is a brief summary of the findings :—

Stomach.—On opening the stomach, three or four large blood-clots were removed. The mucosa is not thickened at any point, and there are no evidences of ulceration.

Duodenum.—The duodenum contains a mass of blood-clot, but there is no thickening of the walls or evidence of ulceration.

As there are no definite pathological findings in the abdomen, it is necessary to open the chest. On removal of the breast-plate, a large mass, about the size of a fist, is seen in the mediastinum just above the base of the heart. This is quite firm in consistency, and appears to involve the various structures of this region.

The heart, aorta, and œsophagus, including the mediastinal mass, are removed intact. The heart, aorta, and œsophagus are laid open. On the inner and anterior wall of the œsophagus, at a point opposite the arch of the aorta, there is found an irregular small opening a quarter of an inch in diameter. This opening is found to be filled with blood-clot, which becomes continuous with a large clot that is present in the œsophagus. This opening leads into the cellular tissue of the mediastinum between the œsophagus and arch of the aorta. Examination of the arch of the aorta reveals a small irregular opening an eighth of an inch in diameter, situated $1\frac{1}{2}$ inches to the left of the great vessels that go to the head and neck. This opening also is found to lead into the same cellular tissue as the opening in the œsophagus. The involved cellular tissue, which constitutes a mass between the œsophagus and arch of the aorta 2 by $2\frac{1}{2}$ inches in diameter, is infiltrated with blood-clot. Further examination reveals, lying in this space, a flattened piece of metal, $1\frac{1}{4}$ inches in length, and sharpened at both ends.

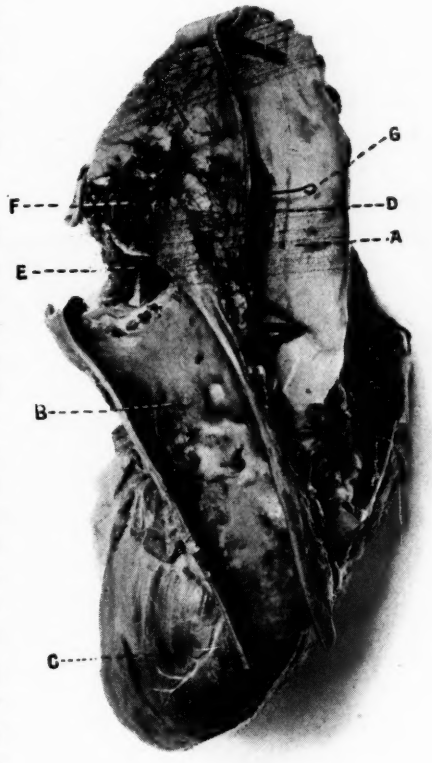


FIG. 404.—Specimen showing the wounded œsophagus and aorta. A, Œsophagus. B, Aorta. C, Left ventricle. D, Opening through œsophageal wall. E, Opening in aortic wall. F, Space in mediastinal tissue filled with clot in which the piece of metal was found. G, Probe indicating course traversed by the piece of metal. ($\times \frac{1}{3}$.)

Piece of metal causing the wounds. (*Actual size.*)

Post-mortem Diagnosis. — Hæmorrhage from injury produced to the walls of the œsophagus and aortic arch by a piece of metal.

The accompanying figures (*Fig.* 404) illustrate the autopsy findings and the cause of the clinical picture. The perforation of the aorta allowed blood to pass into the œsophagus; this trickled into the stomach, and after collecting, either passed into the intestine, giving rise to melæna, or was vomited.

A CASE OF TWO ANEURYSMS RESULTING FROM PENETRATION BY A SMALL SHELL FRAGMENT, ONE OF THE FIRST PART OF THE RIGHT SUBCLAVIAN, THE OTHER OF THE AORTA.

By Lieutenant-Colonel GILBERT BARLING, R.A.M.C.

Patient, age 33, was admitted to No. 1 Australian General Hospital, April 11, 1917, with a diffuse supraclavicular swelling on the right side, and with a small wound two inches above the middle of the right clavicle. The skin over the swelling was somewhat reddened and tumid, pitting slightly on pressure. A thrill could be felt all over the area, and the murmur was conducted more plainly towards the angle of the jaw than towards the axilla. Slight difficulty in swallowing existed; there was a little dyspnœa from time to time; the right pupil was contracted; and there was some hoarseness which suggested interference with one of the vocal cords, but the condition was not ascertained by laryngoscopic examination.

On April 15 the general swelling had diminished considerably, leaving a well-defined tumour about the size of a tangerine orange beneath and external to the lower part of the right sternomastoid. The thrill remained as before, and the murmur had in some degree the buzzing character usually associated with arterio-venous communications.

Radiography showed a foreign body at about the level of the second left costal cartilage and an inch to an inch and a quarter from the middle line; it was observed to move with the heart-beat, but no localization as to depth was carried out. Physical signs indicated fluid in the right pleura to the level of about the fifth rib posteriorly, and there was some displacement of the apex beat outwards.

On April 26, the notes say, "The size of the tumour has undergone no further change, but the skin over it is reddened and œdematous, and there is a little purulent discharge from the entrance wound. The temperature is 100·6° this morning. The radial and temporal pulses on the right side are smaller than on the left." In view of the inflamed condition over the aneurysm, it was thought unsafe to transmit the patient to England. Operation was therefore determined upon, and was carried out on April 28, with the assistance of Colonel Pilcher and Lieutenant-Colonel Quick.

On two previous occasions[1] I had exposed the innominate artery by an angle incision, the vertical limb along the anterior border of the sternomastoid, the horizontal along the inner portion of the clavicle; in these two cases the division of the artery was so high that the access attained was sufficient without removal of any part of the manubrium. The same incision was now adopted; but the division in the innominate was lower than in my previous experience, so by means of Hey's saw and gouge forceps part of the upper portion of the sternum was removed. The common carotid was exposed, and followed down into the innominate. Here, as when the innominate was exposed, the utmost difficulty was experienced in separating the vessel from its accompanying vein. By much expenditure of time this was eventually accomplished

safely. The sheath of the innominate was cleared from the vessel, the aneurysm needle was passed round the artery ready to receive the ligature, and all difficulties seemed to be surmounted, when there was a terrific gush of blood coming from below the level of the aneurysm needle. This was withdrawn, and the hæmorrhage controlled with the fingers. Attempts with forceps to close the source of the bleeding were followed by further hæmorrhage, absolutely flooding the wound, and the finger passed into a cavity, the nature of which was uncertain, whether superior vena cava, an auricle, or part of the aneurysmal sac. A small dry wound-swab was therefore packed firmly over the area whence the bleeding came, other swabs were used to fill the wound cavity, and the patient was returned to bed in fair condition.

Examination showed that pulsation in the subclavian aneurysm had ceased, and the right radial pulse was absent. At the moment it appeared that the manipulations had disturbed clot, which had plugged the wound in the artery; but possibly the change in the aneurysm and radial pulse was due to the firm pressure of the plugging on the origin of the subclavian.

On the second day some of the swabs were removed, others on the following days, and it was intended to attempt to complete the operation on the seventh day after the first failure. On the fourth day the patient was evidently losing ground; his breathing was more distressed; and on the fifth day 59 ounces of sterile blood-stained fluid were withdrawn from the right pleura. There was no real amendment, however, and death occurred on the sixth day, without return of hæmorrhage.

At the autopsy, the wound, mediastinum, pleuræ, and pericardium appeared to be uninfected. The heart, the great vessels, the subclavian aneurysm, and the first rib were removed in a mass. A radiograph showed the foreign body *in situ*, and it was eventually identified in the wall of the pulmonary artery just where the latter leaves the right ventricle.

Dissection showed that the external aneurysm was due to a wound of the first part of the subclavian artery and vein. The sac of the aneurysm was filled with firm laminated clot, and it is doubtful if there was any current through it at the time of death. A second aneurysm was found arising posteriorly from the arch of the aorta just where the first and second portions join; this sac was also filled with firm laminated clot, and it is clear that there was scarcely any current through the sac.

The missile, in its passage downwards and inwards from its point of entry, wounded the first part of the subclavian, passed across the arch of the aorta—this vessel showing wounds of entry and exit—and then lodged in the root of the pulmonary artery without penetrating to the interior of that vessel.

As the innominate vein and superior vena cava were intact, I can only conclude that in passing the aneurysm needle round the innominate, the root of that vessel was somewhat raised, and tore the edge of the second aneurysmal sac, and that from this source the hæmorrhage occurred.

REFERENCES.

[1] *Lancet*, 1905, Sept. 16; *Ibid.*, 1907, Nov. 16.

REVIEWS AND NOTICES OF BOOKS.

Malingering: or, The Simulation of Disease. By A. Bassett Jones, M.B. Lond., and Llewelyn J. Llewellyn, M.B. Lond.; with a chapter on Malingering in Relation to Eye Diseases by W. M. Beaumont. Large 8vo. Pp. 708, 5 plates. 1917. London: William Heinemann. 25s. net.

A most careful and exhaustive treatise upon the subject by the well-known authors of the treatise on fibrositis. It well deserves a place in the library of every medical man who is engaged in Workmen's Compensation practice. After introductory chapters dealing with the history, legal aspects, psychology, and diagnosis of malingering, the subject is considered in relation to diseases of the nervous system, internal diseases, accidental injuries, infections, and hernia, and it concludes with a section dealing with measures for the restriction of malingering. From a surgical point of view the articles on sprained back and allied conditions, and those on the injuries of the joints, are the most valuable. The whole work is marked by wealth of detail, a high degree of critical judgement, and scholarly finish, and it will prove a most valuable work of reference.

Emergency Surgery. By John W. Sluss, A.M., M.D., F.A.C.S., Associate Professor of Surgery, Indiana University School of Medicine. Fourth edition. Pp. 827, with 685 illustrations. 1917. London: William Heinemann. 17s. 6d. net.

The author tells us, in the preface to the first edition, that "this is a Surgery for the general practitioner; written not to instruct his leisure hour, but in the hope some time to serve as a guide out of uncertainty in a time of stress."

The work is a little difficult to criticize from the point of view of the general practitioner in this country, to whom it might have been made more valuable by elaborating the technique of operations he is likely to be called upon to treat by himself, and omitting that of others with which it is hardly likely that he will have to deal personally. In America, the land of vast distances, it is no doubt not only possible but probable that the general practitioner may be called upon to undertake any or every form of emergency surgery; but in this country, specialist help is always so near at hand that much of the material in the book will be quite wasted upon the general practitioner. The attempt to cover such a wide field has necessarily made the details of the minor surgical methods rather meagre, so that the book cannot vie on the one hand with such a volume as Lejars' *Chirurgie d'Urgence*, or, on the other hand, with the many excellent manuals of minor surgery that are to be found in this country. As an example of what is perhaps unlikely to be of use to the general practitioner, we may instance the elaborate directions for exposure and repair of individual nerves. Surely, the most the general practitioner is called upon to do is to re-unite nerves divided in a wound; the rest is a matter for a skilled surgical specialist. Similarly, bone-plating and the operative treatment of fracture of the patella are not matters that fall commonly within the province of the general practitioner.

Among points that are not quite in accord with modern practice may be noted the passage of drainage tubes across the knee-joint beneath the patella (p. 458), and the drainage of an empyema in a child without removal of a portion of rib.

There is an extensive section dealing with the surgery of gunshot wounds. This can hardly be deemed a matter for the general practitioner, and would have been better omitted. There are not enough definite details to make it valuable to the army surgeon, and it is altogether too voluminous for the rare gunshot injuries of civil life.

Nerve Wounds: Symptomatology of Peripheral Nerve Lesions caused by War Wounds. By J. TINEL, late Chef de Clinique at La Salpêtrière, with Preface by PROFESSOR DEJERINE; translated by FRED. ROTHWELL; revised and edited by CECIL A. JOLL. Pp. xii + 317, with 323 illustrations. London: Baillière, Tindal & Cox. 15s. net.

THIS work represents the outcome of the examination by both clinical and laboratory methods of a number of military cases. It is a publication only made possible by the co-operative work of a group of clinicians.

It deals chiefly with the details of 639 cases, and the French text of which it is the translation appeared only a little more than a year after the outbreak of the war. The very careful details given and illustrated of the different symptoms, paralytic, functional, and contractional, form a more precise picture of the various lesions than has ever before been published. The happy association of anatomical description with clinical illustration makes the work very convincing. The first section deals with general principles, including the histology of divided and regenerating nerves, and the general principles of diagnosis. The second and third parts describe the various lesions of the special nerves of the upper and lower limb. Of particular value is the distinction of the different groups of symptoms associated with various degrees of nerve interruption: these being complete interruption, compression, irritation or neuritis, and the neuralgic type.

From a surgical point of view, the most serious criticism we have to make is that the section devoted to treatment is compressed into about seven pages. It is a matter of urgent importance that an authoritative statement should be made as to the essentials in operative technique, and that this should be founded not merely on personal opinion, but upon the actual results observed at long periods after operation. According to the present authors, spontaneous recovery takes place in over sixty per cent of all cases, and therefore surgical intervention is not called for unless, at a period of several months after injury, there is no evidence of regeneration in the peripheral segment. Clear indication is given that direct end-to-end suture after excision of neuromata is the ideal to be aimed at by operation. The use of a sensory nerve as a graft is considered to be justified, but no cases are quoted to sustain this opinion. The use of flaps of living or dead tissue to surround the joined nerve is condemned. The numerous illustrations are clear, and add a great value to the best book on the subject which we possess at present.

Massage, its Principles and Practice. By JAMES B. MENNELL, M.A., M.D., Medical Officer Physico-therapeutic Department, St. Thomas's Hospital and London Military Orthopædic Hospitals. With an Introduction by Sir ROBERT JONES, Military Inspector of Orthopædics. Pp. xvi + 352, with 135 illustrations. 1917. London: J. & A. Churchill. 8s. 6d. net.

DR. MENNELL is an enthusiast, but a very sane enthusiast, and the present work greatly gains from this fact. It is not intended as a text-book for teaching massage, but rather as a presentation of the rôle of massage in the treatment of disease, and a discussion of its rationale.

The whole principle of successful orthopædic treatment is now recognized to be a close co-operation between the different methods, surgical, physico-therapeutical, and mechanical. It is, however, given to but few to be able quite intelligently to prescribe and carry out all these different forms of treatment. The surgeon must be dependent upon experts in massage and in electricity for the carrying out of these particular methods; but he must know sufficient both of principles and details to be the master and not the servant of the experts. The author has never lost sight of the teaching of the French surgeon, Lucas-Championnière, which was to the effect that the great value of massage is its reflex or nervous influence as a soothing agent, and that movement, natural and free, painless and voluntary, is the end and object of all massage treatment.

We admit that we are wholly converted to these views, and we most heartily hope that Dr. Mennell will convince all those who have to practise massage for

military patients. That massage is only a means to an end, and that this end, namely, voluntary movement, should be borne in mind from the very outset, is most important. But the other point—which is still more often overlooked, and which we should imagine is not accepted by many of the teachers and practitioners of massage—that massage should be primarily sedative and not stimulant, is equally important.

The book is concerned for the greater part in considering the massage treatment of injured limbs, but it contains also a consideration of its relation to nervous, circulatory, and digestive disorders.

The chapters relating to physical exercises deal almost entirely with a simple type of pulley machine, whereby all ordinary exercises can be carried out by the patient with a very compact and simple gymnastic outfit. But we think that however admirable this system of resisted movements may be, it does not fulfil all the functions which other systems such as Zander's perform. We quite realize that the author disapproves of these systems, but we think the book would have been of greater value if he had taken the trouble to discuss the theory, possibilities, and limitations of the various pendulum machines.

SHORT NOTES ON BOOKS.

Ligations and Amputations. By PROF. A. BROCA, translated by ERNEST WARD, F.R.C.S. Pp. 282, 510 illustrations. 1916. Bristol: John Wright & Sons Ltd. 8s. 6d. net. This book was favourably reviewed on the appearance of the original in French. It represents the classical teaching of Farabeuf, many of the illustrations being from this author's work. It is undoubtedly a most valuable book at the present moment because of its clearness, precision, and brevity.

A Handbook of Surgical Operations for the use of Students. By K. K. CHATTERJI. Pp. 229, plates 26, many in colours. 1916. Calcutta: Butterworth & Co. (India) Ltd. 7s. d6. net. A short and concise account of the ordinary operations performed on the dead subject, illustrated by numerous diagrammatic figures.

Acute Appendicitis. By C. HAMILTON WHITEFORD. Pp. 72. 1917. London: Harrison & Sons. 4s. net. A small book representing the result of the author's experience for over twenty-five years; his general remarks are so much in consonance with ordinary teaching that it is difficult to select any special points for notice.